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GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
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DEVELOPMENT OF CLOUD-BASED INTELLIGENT HEALTHCARE SYSTEM USING DIGITAL TWIN

Sara Jamal HUSSEIN

Master's Thesis

DEPARTMENT OF COMPUTER ENGINEERING

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THESIS APPROVAL

This thesis, which was prepared according to the thesis writing rules of the Graduate School of Natural and Applied Sciences, Fırat University, was evaluated by the committee members who have signed the following signatures and was unanimously approved after the defense exam made open to the academic audience.

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DECLARATION

I hereby declare that I wrote this Master's Thesis titled " Development of Cloud-Based Intelligent Healthcare System Using Digital Twin " in consistent with the thesis writing guide of the Graduate School of Natural and Applied Sciences, Firat University. I also declare that all information in it is correct, that I acted according to scientific ethics in producing and presenting the findings, cited all the references I used, express all institutions or organizations or persons who supported the thesis financially. I have never used the data and information I provide here in order to get a degree in any way.

29 January 2021

Sara Jamal HUSSEIN

PREFACE

Above all else, my thanks are routed to GOD for inspiring me with forbearance and power to perfect the research.

I would like to express my heartfelt thanks for his support and patience to my consultant, Prof. Dr Mehmet KARAKÖSE. I'm thankful for his support in my tough study times and I appreciate that.

Until the end of my life, my advisor, I am grateful for the information he gave me and for his effort and thank you very much, he will never forget his contribution in my academic life and I will always be grateful.

I would like to express my deepest gratitude to my family, if it was not for their courage, I would not be here. I want to say that I love them very much by feeling that they are behind me at all times and under all circumstances, and today I am sad because they are not with me but their hearts are always with me, I know.

I am also very grateful to all my friends for their support and tolerance.

I also would like to express my gratitude to all academic staff of Computer Engineering department in the University of Firat and my special thanks to my friends that were always beside me and never stopped giving the motivation.

Sara Jamal HUSSEIN
ELAZIG, 2021

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Digital twins are one of the most popular digital trends. In this contribution, we will briefly review the concept of digital twins and the possibilities for new industrial applications.

The digital twin established and how it is practiced is discussed, the digital twin was a technology trend in these years. A digital twin is a term used to describe physical assets or mechanism in a computerized or digital version. The digital twin contains one or more sensors that collect data to represent real-time information about the physical asset, and in the research create an intelligent a digital copy for mechanical ventilators using the cloud systems, create an intelligent monitoring system.

Our final step in constructing the digital twin model is to create the twin in the digital environment. At this stage, methods that are on the rise in computer science such as simulation, prediction and an intelligence system come into play. The digital twin, which is in constant communication with its physical twin, processes the data and produces results in different scenarios, while at the same time not missing any real data that may come from the physical environment and, if necessary, updating its studies based on new real information.

Simulator production is useful and advantageous for respiratory control studies. Artificial mechanical ventilation by the use of an artificial ventilator is a common procedure that is not adequate to sustain oxygenation at a degree of protection for a patient who has an abnormality in his respiratory system or his uncontrolled breathing. During inspiration, it acts to supply an amount of airflow into the lungs and during an expiration process, it extracts air from the lungs.

The ventilator itself is difficult when setting conditions, with or even when all show ventilator waveform is known. In this research, creating an intelligent healthcare system for mechanical ventilator using the cloud system also applies to applications offered as network services and to system hardware and software in the data centers that provide those services. Cloud computing is the provision of a variety of services over the internet, including data warehousing, servers, databases, networks, and software. Cloud-based storage allows files to be stored in a remote database and downloaded on demand and digital twin, we use simulation software to present a simplistic mechanical ventilator model to use in a routine ventilation study as a basic tool. A modeling and simulation process based on the mathematical model, which has been verified in earlier studies, is implemented on the MATLAB program. By utilizing the Simulink and GUI of MATLAB, real-time simulation and signal monitoring of respiratory control with multilayer functional modules are realized.

The simulator production is useful and advantageous for breathing control investigations it means to create an intelligent healthcare system. If the patient is male or female, I take all the data and include it in the content of the application, we take 30 samples within 30 hours, taking each data hourly after receiving data from the patient, the patient's blood pressure, pulse pressure, heart rate, the oxygen level in the human body

draws graphs for all parts and shows all the averages of the blood pressure, pulse pressure, heart rate, the oxygen level in the human body in this application.

The most important task in this research the intelligent healthcare system such as mechanical ventilator gauge the oxygen saturation in the human body and show the message describe the patient’s state which percentage need the oxygen.

The simulator implements monitoring windows to observe the respiratory waveforms of pressure, flow rate, and tidal volume.

In practice, we show the patient's blood pressure, pulse heart rate and the oxygen level in the blood, and after showing the average, the mechanical ventilator application draws graphs showing all the input parameters and output the graphical for tidal volume, flow rate, pressure then all output parameters for other variables normal ranges are compared to all output parameters, and After comparing all output parameters to the normal ranges, we can see them all as a report.

Keywords: Digital Twin, Healthcare Systems, Intelligent Systems, Cloud Systems, Modeling and Simulation.

ÖZET

Dijital İkiz Kullanılarak Bulut Tabanlı Akıllı Sağlık Sisteminin Geliştirilmesi

Sara Jamal HUSSEIN

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Dijital ikizler, en popüler dijital trendlerden biridir. Bu katkıda, dijital ikiz kavramını ve yeni endüstriyel uygulamalar için olanakları kısaca gözden geçireceğiz.

Kurulan dijital ikiz ve nasıl uygulandığı tartışılırken, dijital ikiz bu yıllarda bir teknoloji trendiydi. Dijital ikiz, fiziksel varlıkları veya mekanizmayı bilgisayarlı veya dijital bir versiyonda tanımlamak için kullanılan bir terimdir. Dijital ikiz, fiziksel varlık hakkında gerçek zamanlı bilgileri temsil etmek için veri toplayan bir veya daha fazla sensör içerir ve araştırmada, bulut sistemlerini kullanan mekanik vantilatörler için akıllı bir dijital kopya yaratarak akıllı bir izleme sistemi oluşturur.

Dijital ikiz modeli oluşturmadaki son adımımız, dijital ortamda ikizi yaratmaktır. Bu aşamada simülasyon, tahmin ve zeka sistemi gibi bilgisayar biliminde yükselişe geçen yöntemler devreye giriyor. Fiziksel ikiziyle sürekli iletişim halinde olan dijital ikiz, verileri işleyip farklı senaryolarda sonuçlar üretirken, aynı zamanda fiziksel ortamdan gelebilecek gerçek verileri de kaçırmamakta ve gerekirse çalışmalarını temel alarak güncellemektedir. Yeni gerçek bilgiler üzerine.

Simülatör üretimi, solunum kontrol çalışmaları için yararlı ve avantajlıdır. Suni bir ventilatör kullanılarak yapılan yapay mekanik ventilasyon, solunum sisteminde bir anormallik veya kontrolsüz solunumu olan bir hasta için oksijenasyonu belirli bir koruma derecesinde sürdürmek için yeterli olmayan yaygın bir prosedürdür. İnspirasyon sırasında akciğerlere bir miktar hava akışı sağlama görevi görür ve bir ekspirasyon işlemi sırasında akciğerlerden hava çeker.

Ventilatörün kendisi, tüm vantilatör dalga formu bilindiğinde veya hatta tüm vantilatör dalga formu bilindiğinde koşulları ayarlarken zordur. Bu araştırmada, bulut sistemi kullanarak mekanik ventilatör için akıllı bir sağlık sistemi oluşturmak, ağ hizmetleri olarak sunulan uygulamalar ve bu hizmetleri sağlayan veri merkezlerindeki sistem donanımı ve yazılımı için de geçerlidir. Bulut bilişim, veri ambarlama, sunucular, veritabanları, ağlar ve yazılım dahil olmak üzere internet üzerinden çeşitli hizmetlerin sağlanmasıdır. Bulut tabanlı depolama, dosyaların uzak bir veritabanında depolanmasına ve talep üzerine ve dijital ikiz olarak indirilmesine izin verir; basit bir mekanik ventilatör modelini temel bir araç olarak rutin bir ventilasyon çalışmasında kullanmak üzere sunmak için simülasyon yazılımı kullanırız. MATLAB programı üzerinde daha önceki çalışmalarda doğrulanan matematiksel modele dayalı bir modelleme ve simülasyon süreci uygulanmaktadır. MATLAB'ın Simulink ve GUI'sinden yararlanılarak, çok katmanlı fonksiyonel modüller ile solunum kontrolünün gerçek zamanlı simülasyonu ve sinyal izlemesi gerçekleştirilir.

Simülatör üretimi, solunum kontrolü incelemeleri için yararlı ve avantajlıdır, bu da akıllı bir sağlık sistemi oluşturmak anlamına gelir. Hasta erkek ya da kadın ise tüm verileri alıp uygulama içeriğine dahil

ediyorum, 30 saat içerisinde 30 numune alıyoruz, her veriyi hastadan veri aldıktan sonra saat başı alıyoruz, hastanın tansiyonu, nabız basıncı, Kalp atış hızı, insan vücudundaki oksijen seviyesi tüm bölümler için grafikler çizer ve bu uygulamada insan vücudundaki kan basıncı, nabız basıncı, nabız, oksijen seviyesinin tüm ortalamalarını gösterir.

Bu araştırmadaki en önemli görev, mekanik vantilatör gibi akıllı sağlık sistemi, insan vücudundaki oksijen satürasyonunu ölçer ve oksijene ihtiyaç duyan yüzde hastanın durumunu tanımlayan mesajı gösterir.

Simülatör, basınç, akış hızı ve tidal hacmin solunum dalga biçimlerini gözlemlemek için izleme pencereleri uygular.

Pratikte, hastanın kan basıncını, nabız kalp atış hızını ve kandaki oksijen seviyesini gösteririz ve ortalamayı gösterdikten sonra, mekanik vantilatör uygulaması tüm giriş parametrelerini gösteren grafikler çizer ve tidal hacim, akış hızı, basınç için grafik çıkarır. diğer değişkenler normal aralıklar için tüm çıktı parametreleri tüm çıktı parametreleriyle karşılaştırılır ve tüm çıktı parametrelerini normal aralıklarla karşılaştırdıktan sonra, hepsini bir rapor olarak görebiliriz.

Anahtar Kelimeler: Dijital İkiz, Sağlık Sistemleri, Akıllı Sistemler, Bulut Sistemleri, Modelleme ve Simülasyon

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ABBREVIATIONS

Abbreviations

DT	: Digital Twin
IoT	: Internet of Things
IT	: Information Technologies
AI	: Artificial Intelligence
NASA	: National Aeronautics and Space Administration
ETT	: Endotracheal Tube
C	: Compliance
IS	: Inspiratory Rate
Flow	: Flow Rate
h	: Height
Max Mv	: Maximum Minute Ventilation
Min Mv	: Minimum Minute Ventilation
IBW	: Ideal Body Weight
RR	: Respiratory Rate or Respiratory Frequency
Max Vt	: Maximum Tidal Volume
Min Vt	: Minimum Tidal Volume
Vt or TV	: Tidal Volume
PIP	: Peak Inspiratory Pressure
Pplat	: Plateau Pressure
Raw	: Airway Resistance
PEEP	: Positive End Expiratory Pressure
TCT	: Total Cycle in One Breath
Paw	: Mean Airway Pressure
P/F Ratio	: PaO_2 / FiO_2 Ratio
OI	: Oxygen Index
PaO_2	: Arterial Oxygen Partial Pressure
FiO_2	: The Fraction of Inspired Oxygen
PEER	: Peak Expiratory Flow Rate
SaO_2	: Saturation of Percentage Oxygen
CPPS	: Cyber-Physical Production System
BIM	: Building Information Model
GUIs	: Graphical User Interfaces

1. INTRODUCTION

A digital twin is a digital representation of real-world instruments, the main principle for all participating organizations during their life cycle is to create a digital twin, processes or even individuals also called a "digital shadow". The digital twin gathers and connects all knowledge about the state and use of physical entities to knowledge about the status of their counterparts and provides an assistive response to changes, thus improving their use. The digital twin is an active simulation aimed at running a physical, economic, socio-technical, or business system "real" in parallel and interacting with them. Throughout engineering, digital twins also perform very rich and efficient multi-parameter models. E.g., in the case of complex differential equation structures, they can represent an entity like the business-process model instantiation. The actual analogue-to-digital twin communicating couple forms a cyber-physical production system (CPPS). The key concept is to establish a digital twin for all participating organizations during their life cycle; digital twins are entirely generated based on their physical counterpart's requirements, which record all their changes and developments, digital twins include data from the background of a system or computer, domain experts and even data from other third-party entities, processes and systems. It allows a digital twin to have information on its physical counterpart and its current status updates. When converted into a digital twin, the data processing technique can be used in different ways: E.g., from IoT devices; a model for the performance of calculations and scenarios for reducing time and cost for product design or the implementation of complex systems; finally, as digital twins can easily be run in isolated environments, they can, without affecting operating processes, be carefully evaluated (e.g., in security actions). Development is possible with many significant scientific research achievements in many areas, such as data assimilation, high-efficiency computing for real-time simulations, model order reduction, visualization, data-driven modeling and machine learning etc. In the development of digital twins, several of the main scientific research achievements have been made possible. The papers in this special issue demonstrate that there has already been much advancement but, simultaneously, new work and algorithms are crucial, so those complex systems can be simulated in real-time, treated data and optimized.

In our opinion, the digital twin in the coming few years will become the main research subject, since digital twins are not monolithic objects or data models, but consists of different aspects of digital representation, feature, models, interfaces, etc. From a production perspective and a technological perspective, it is clear that digital twins carry out different activities, for example:

• Self-description by using specific attributes and configuration data parameters, for example for self-identification, for easy connection of machines and components to MES and other IoT industrial solutions [1].

• Explanation of the skills, including the control code pieces that result in a final control system fitting the assembly of components and their respective control logic pieces. This leads to a PLUG and WORK that can be connected to and incorporated into new components at runtime at a functional level [2].

• Data from machine learning were obtained from models of the right runtime conduct of a computer, a line, or an entire assembly store [3].

• Online and offline simulation, including several simulated forms such as virtual commissioning or physics simulation in which the generated products interact in the simulation of the finite elements with kinematic machines. To arrive at an integrated simulation model, various models will preferably be able to communicate. To date, one of the principals uses for simulation of a digital twin has been; this is a very specific concept, as we are finding out here [3].

• Machines and other industrial tools, buildings and facilities representing automated factories. Building Information Model (BIM), as long as it includes relevant data [3].

• Services offered to its users by a cyber-physical component [3].

• IT protection, certificate management, right of access, version administration and digital twin compatibility controls [3].

Digital twin actual virtual duplicates of machines or frameworks are revolutionizing the trade. Driven by data collected from sensors in the period these advanced computer models replicate nearly every facet of associate in care product handle or profit. Various major corporations as of currently utilize digital twins to identify problems and increment proficiency [4]. Several corporations and areas as of currently utilize digital twin to identify issues and increment productivity [5]. With the headway of knowledge technologies notably the event of the unused era of information technologies (New ITs) like the Internet of things (IoT), cloud computing huge knowledge analytics and Artificial Intelligence (AI) the medical care method is greatly fast. Through the convergence of the physical and virtual worlds, medical care is turning into one among the most drivers of innovation in all sectors [6]. Digital twins are advanced copies of physical gadgets that data researchers and IT experts will use to run recreations before real gadgets are structured and sent. We tend to also be dynamic the approach innovations like IoT, AI and analytics are organized. A digital twin may also be the digital transmission of the actual material, whether living or not [7]. The digital twin may be a collection of virtual info creates that depicts a possible or honest to goodness physical created the factor from the miniaturized scale atomic level to the large-scale geometrical level. At its excellent, any info that may be gotten from evaluating a physically factory-made factor may be gotten from its digital twin [8]. In the following Table 1.1 definition the digital twin in a different field.

Table 1.1. Definitions of the digital twin in the scientific literature

Reference	Definition	Use	Field
Shafto et al. (2010) [9]	"An integrated multi-physics, multi-scale, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its corresponding flying twin."	"Simulating the flight beforehand, mirroring the state of physical twin, analyze the cause of the anomaly, predictions."	Aeronautics
Tuegel et al. (2011) [9]	"Ultrahigh fidelity model of an individual aircraft", which is "ultrarealistic in geometric detail, including manufacturing anomalies, and in material detail, including the statistical microstructure level."	"Act as a virtual sensor, integrating models, storing information, maintenance optimization."	Aeronautics
Tuegel (2012) [9]	"A tail number specific cradle to grave ultrarealistic as built and maintained a computational model of an individual aircraft. "An integrated collection of sub-models."	"Estimation the remaining lifetime, managing the information about the configuration, maintenance optimization, virtual testing."	Aeronautics
Glaessgen & Stargel (2012) [9]	"An integrated multi-physics, multi-scale, probabilistic simulation of an as-built vehicle or system that uses the best available physical models, sensor updates, fleet history, etc. to mirror the life of its corresponding flying twin."	"Certification, fleet management, monitoring, and mitigating anomalous events, forecast the health of the vehicle or system."	Aeronautics
Smarslok et al. (2012) [9]	"Enables condition-based fleet management by tail number through numerical simulation of the structural response to the same flight spectrum as experienced by the physical system."	"Condition-based fleet management by tail number, life prediction, simulations, risk mitigation."	Aeronautics
Lee et al. (2013) [9]	"The coupled model" … "of the real machine that operates in the cloud platform and simulates the health condition with an integrated knowledge from both data-driven analytical algorithms as well as other available physical knowledge."	"Integrate, manage and analyze machinery or process data during different stages of the machine life cycle to allow health condition monitoring."	Manufacturing
Cerrone et al. (2014) [9]	Not explicitly defined.	"Predicting the crack path by modeling as manufactured geometry".	General/ aeronautics
Grieves (2014) [9]	"Digital equivalent to a physical product."	"Real-time visualization of factory state. Comparing the desired result and the actual result."	Manufacturing
Bazilevs et al. (2015) [9]	"A high-fidelity structural model that incorporates fatigue damage and presents a fairly complete digital counterpart of the actual structural system of interest."	"Fatigue damage prediction."	General

Rios et al. (2015) [9]	"'As-built' digital structure of a physical product."	"Defining, simulating, predicting, optimizing and verifying the product along with its life lifecycle."	General/ aeronautics
Rosen et al. (2015) [9]	"Realistic models of the current state of the process" and system "behavior in interaction with its environment in the real world."	"Represents the full environment and process state. Forward simulations to support the decision making of an autonomous system."	Manufacturing
Tuegel (2012) [9]	"A tail number specific cradle-to-grave ultra-realistic as-built and maintained the computational model of an individual aircraft. An integrated collection of sub-models."	"Estimation the remaining lifetime, managing the information about the configuration, maintenance optimization, virtual testing."	Aeronautics
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Rosen et al. (2015) [9]	"Realistic models of the current state of the process" and system "behavior in interaction with its environment in the real world."	"Represents the full environment and process state." Forward simulations to support the decision making of an autonomous system."	Manufacturing
Uhlemann et al. (2017b) [9]	Not explicitly defined	"Enhance transparency, improve control and optimization of the process by offering near real-time data."	Learning
Alam & El Saddik (2017) [9]	"An exact cyber copy of a physical system that truly represents all of its functionalities."	Connect physical things to the application layer of CPS. "Monitoring, diagnostics, prognostics."	Smart City/ vehicles
Negri et al. (2017) [9]	"Virtual and computerized counterpart of a physical system that can be used to simulate it for various purposes, exploiting a real-time synchronization of the sensed data coming from the field."	"Health analysis, monitoring the system, maintenance optimization, mirroring the physical twin, predicting the system behavior, optimization of 'the system operation."	Literature review
Tao et al. (2018) [9]	"An integrated multi-physics, multi-scale, and probabilistic simulation of a complex product that uses the best available physical models, sensor updates, etc., to mirror the life of its corresponding twin."	"A holistic solution for PLM data, improving the design, manufacturing, and operation of a product, simulations, predictions, virtual training."	Design/ Manufacturing /operation of the product (PLM)

It is difficult to describe the general concept of a digital twin since the needs and specifications of a digital twin depend on the area. The mistake of the notion of a digital twin makes it possible in any study to define it separately.

1.1. Digital Twin Development

One of the applications for technical advances used in the industry is the digital twin process. With the assistance of computer software, the digital twin can be defined as the development of physical asset reflection. With the simultaneous upload of financial and non-financial information about the organization and its owners, the profit from the audit will improve.

In 2001, the "digital twin" concept, one of the first to use “Michael Grieves” "Product Lifecycle Management" digital twin model as noted in the book are three main factors to speculate on a structure, the first digital media device to be formed in twin tools and equipment or factory. Secondly; to provide the digitized data must be obtained. The physical environment of some data to move to digital platforms should be poured on mathematics and must be translated into the 1's and 0 digits in some computer coding language information. It is possible that contact sensors. data from sensors, and integrated with corresponding systems previously generated and combined with data previously transferred to the digital medium is made ready digital modeling. The third and final stage; a mirror is formed in the digital environment. At this stage the simulation, the rise estimation algorithms and methods utilized in computer science such as artificial intelligence. Digital twins who are in constant communication with the physical, data removing process and results in different scenarios but also the physical environment of the future should there be any real data from real information from the kidnapping and basing updating.

Special digital models defined as digital twins offer advances in technology is one of the advantages. In the traditional process; identifying problems, increasing productivity studies, decision-making mechanisms, a real machine, tools and people in the physical environment based on data. While most businesses have limited access to detailed data on these issues, smart decision making to establish data-based methods and misconception it may decrease. For this reason, the system is prepared in a detailed, timely and tailored systematic. Need to be installed. Because unlike an analysis environment where the entire ecosystem can be seen studies are conducted on data focused on some points. Along with the digital twin, a specific it is possible to move the medium or machine (even the entire factory) to digital media. In the real world, the data generated (in the physical field) will also be reflected and generated on the digital platform, and this will be different. It will allow producing and working on scenarios.

The road map published in 2010 by the concept of digital twin NASA and was heard for the first time by the public. The digital twin is defined as dynamic software model of a physical object or a system. In other words, digital media is the twin of the real-life twins. Digital twin analyzes real-world conditions, simulating, respond to changes, be used to improve operations. Within a few years, billions of objects to be met with a digital twin, a physical object or system, will be represented by a dynamic software model. The digital twin of physical assets, people with a digital representation of the facilities and environment, between businesses and simulation processes, by creating a real-world analysis and control system will provide a more detailed way in the digital representation. Business, digital twin "discharging a live model, which is a consequence of business" as characterized. Do not use the digital twins and that it should be an economic rationale or justification for an optimization or cost reduction is a combination of these reasons [10]. The turbine power plant in a digital twin corrected by forming irregularities detected by this digital turbine is provided and twelve million dollars in savings.

Billions of objects soon are expected to be represented by a digital twin. For example, the digital twin is monitored about 500 thousand in a general electric plant in turkey. In different environmental conditions of the object to determine how it reacts to how it works and the resulting reaction that occurs in the real world with physical data and comparisons can be detected using the sensor results. According to this comparison result; digital twin performing analysis and simulation of real-world conditions, create and respond to change operations can be used to make it better [11].

Factors, cities, countries have digital twins, as well as individuals, have digital twins, which will reduce the risk of illness. The use of smart machines and robotic surgery are preliminary studies of the digital twin application, which will be a breakthrough in the medical world. The Da Vinci robot, used today as a surgical robot in medicine, was drawn by Leonardo Da Vinci in 1492. With the drawing he named as Vitrivius Man, Da Vinci determined the ideal measurements of the human and tried to make the most accurate copy. In the literature, Da Vinci's self-driving car was named the first robotic vehicle and the robot knight was named the first humanoid robot. Using the anatomy, Da Vinci observed how muscle work gives strength to bones and designed a humanoid machine that can work on the same principles. Due to the inability to produce this invention, which is different from Da Vinci's other discoveries, it remained a robotic knight for entertainment purposes. In 2002, robotic expert Mark Rosheim produced a simulation of this system that works with rollers and wheels. Later, Rosheim used some of these designs as NASA's robots [12]. In medicine, working with a cadaver to understand the human body can also be compared to an analog twin. Advances in medicine are closely related to the digital world. The digital stethoscope, which is indispensable for doctors, has the feature of recording and storing heartbeat and breathing sounds. In the future, the stethoscope will collect large amounts of data that relate to diagnostic data and treatment information and will assist in diagnosing the doctor. Daily jobs such as learning machines, tools, speakers and hospital equipment, patient records, patient databases and preliminary examinations will be performed by smart machines in the digital environment thanks to artificial intelligence.

A digital twin is a computer program that uses real-world data to produce models that can simulate the operation of a product or process. IoT (Industry 4.0), intelligent systems, cloud services and software analysis can be integrated into these projects to increase performance.

Creating this will make it possible to change patterns of strategic infrastructure, avoid the failure of costly physical things, advanced analysis, monitoring and forecasting capabilities, testing methods and resources to be used.

In the following Figure 1.1 appear all stages for digital twin development.

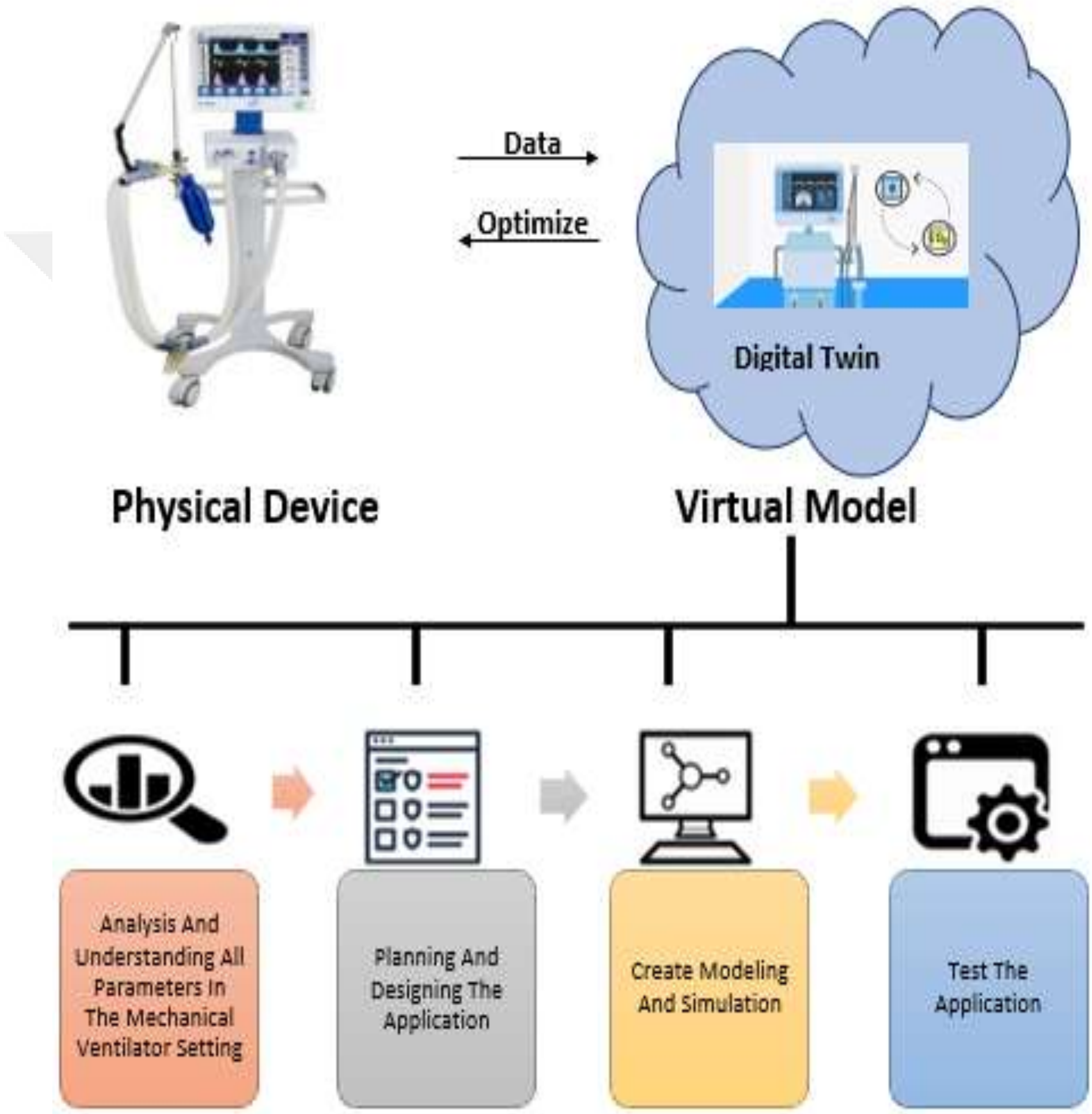


Figure 1.1. Digital twin development for a medical device such as mechanical ventilator

The digital twin can be defined as a data-rich record that lasts a lifetime of a person along with intelligent system-powered models that can "query" the data to answer clinical questions.

Healthcare system is beginning to take advantage of this strong new platform now, the first step analysis of the intelligent healthcare system creates a report using cloud-based for creating a digital twin application to get information on the cloud-based and change to digital twin model after creating system definition and simulation, the last step is testing application the using digital twin is developing intelligent healthcare system is has a lot of benefit for examples more efficient supply and delivery chains, Improved product quality, and enhanced insight into the performance of your products, in multiple real-time applications and environments, reduced risk in various areas including product availability, marketplace reputation and more, faster production times.

we are making a virtual copy of intelligent healthcare systems, e.g., mechanical ventilator, the mechanical ventilator receives real data’s, and use the real data's for creating the digital copy, cloud system at the storage place where all data are collected, a cloud system is a storage place where all data can be accessed at any time or anywhere.

In the first stage, it is necessary to analyze in a very detailed way and understand all parameters related the mechanical ventilator, and as the second stage, the planning and design of the application were done in great detail. As the third stage, the intelligent healthcare system, namely the mechanical ventilator, makes modeling and simulation. In this stage, we can use the cloud system to use all the data from where it is collected, we use certain programs to make simulation at this stage the most popular programs. In this thesis, we use MATLAB to use this application is one of the most efficient and best programs to be very fast in MATLAB in the last stage, when there is an application in the combination of the intelligence healthcare system and cloud system used to make digital twins, this application is tested and checked if there is any problem or not.

1.2. State of Art

Digital twin technology, in its simplest definition, means a virtual copy of a product, a building, and even a person's real-life movements in detail. With the help of digital twins, all stages of a service or product can be detected in a much more cost-free and risk-free manner before the production stage, all possible scenarios are tested on digital copies and it is possible to launch the product to be used in the real world in the most perfect form. This technology, which we encounter with many examples, has the potential to take the whole world to a whole new place. Nowadays, it is being said that digital twins of people will be created and the rate of this technology being preferred by people will increase rapidly in a short time. It is claimed that the greatest advantage of this technology will be in the field of health. So, whatever you eat, your digital twin will eat, and whatever discomfort you complain about, your digital twin will suffer from those ailments.

There are very few articles and studies in the literature about intelligent healthcare systems using a digital twin. All of the work done in the literature related to digital twin to this research.

Therefore, you will have a chance to have information about the diseases you will catch in the future. Imagine, your digital twin "If you continue to smoke in this way, you will catch lung cancer in a year," it will warn you. Thus, we will be able to diagnose the diseases much earlier and have the opportunity to live a healthier and more peaceful life.

Yu Feng et al. [13] "Personalized medicine is commencing to replace the present one size fits all" approach. Digital twin and respiratory organ aerosol dynamics modeling platform is a noninvasive tool for individualized treatment designing.

In 2012, highly fatal lung cancer killed 1,6 million people and cost billions of healthcare worldwide. The goal is to develop a good, customized respiratory organ attention coming up with a tool to deliver the correct dose of the right drug at the right time and site to the desired patient. Targeted pulmonary drug delivery approach is one form of customized pulmonary healthcare planning. It's one way to target the right upper lobe using the "Controlled Air-Drug Stream Method". Ancient in vitro and in vitro studies are restricted and not decent for the customized treatment set up development purpose. There is a lack of organizational versatility in animal research and clinical study. There should be multiple choices. Models based on the framework of the dynamics for the measurement of fluid particles are critical in exploring alternative designs for the analysis. Due to the lack of conventional in-vitro and in vitro methods, the in-silicon methodologies will fill the void. Reconstruction of a full pull system to model the complete breathing cycle inspiration-expiration on the transport and deposition of particles is a foresight task. The study looked at CFPD simulation with error bars and multi-scale model to bring the simulation to health endpoints. i.e., translocations in the whole body. The customized pulmonary healthcare manager will provide an integrated solution to target targeted lung sites. It's simple, non-invasive, accurate, convenient to use and the best feature is that with your individualized digital twin, the preparation is patient-specific. The APP will collect morphological parameters dependent on the patient-specific CT / MRI details of the human respiratory system. The workflow Figure 1.2 will be approached soon in a single App, which is built using thorough simulation specifications using software like ANSYS ACT in Python.

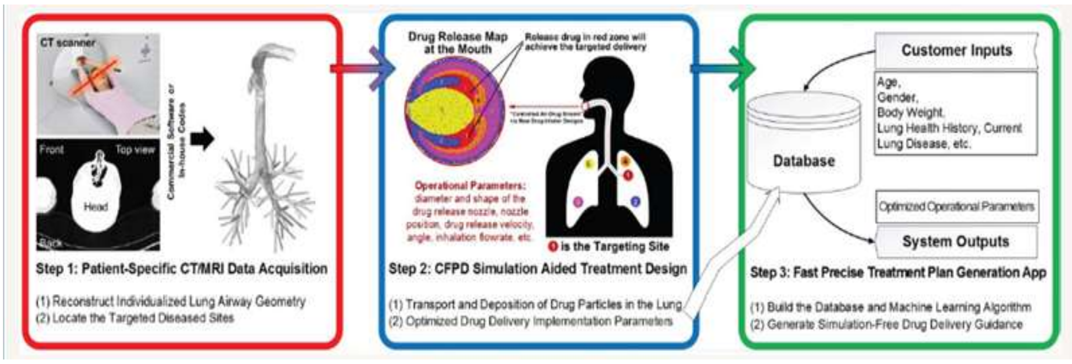


Figure 1.2. Schematic and customized targeted drug delivery platforms in silico clinical trial preparation [13]

Ying Liu et al. [14] technologies such as cloud computing, the internet of things and the mobile Internet are already commonly used in the area of healthcare.

The digital twin is an important way to resolve information-physical interaction and integration bottleneck. It can provide great support for older adults through online healthcare services as extended to education. The paper provides the framework and application strategies of digital twin aid within the cloud. It was planned to resolve the matter of real-time superintendence and accuracy of crisis warning for the old.

Bergthor Björnsson et al. [15] in this article, it talks about the concept of digital twins for personalized medicine; a patient has a local symptom of the disease this patient's digital twin is made in an unlimited number of copies based on the calculation network models of thousands of disease-related variables. Each twin is calculated with one or more of thousands of drugs. This results in a patient's digital therapy. For the patient's treatment, the medication with the greatest effect on the digital twin is chosen. which drug has the best effect on the digital twin gives real medicine to the real person.

Shyan Lung Lin et al. [16] the LabVIEW platform combines a simulation and modeling approach based on an optimal chemical-mechanical respiratory control model, as verified in previous studies. By exploitation the LabVIEW graphic programming language, multi-layer functional module respiratory management can be simulated and signal-controlled over time. The breath control simulator was developed together with the ideal model to reduce the problem of neuromuscular pressure profile parameters. The simulator offers control windows to better control immediate pressure, ventilation and lung volume for respiratory curves. Simulators can be built-in respiratory control and in biomedical respiratory engineering physiological training.

The same approach was used for mathematical modelling in this article: Gas exchanger, Chemoreceptors, Neuro-mechanical effector, optimal controller, work rate index, mathematical derivation and optimization. A block diagram of Figure 1.3 illustrates the mathematical modeling of the optimum mechanical chemical control model for respiration.

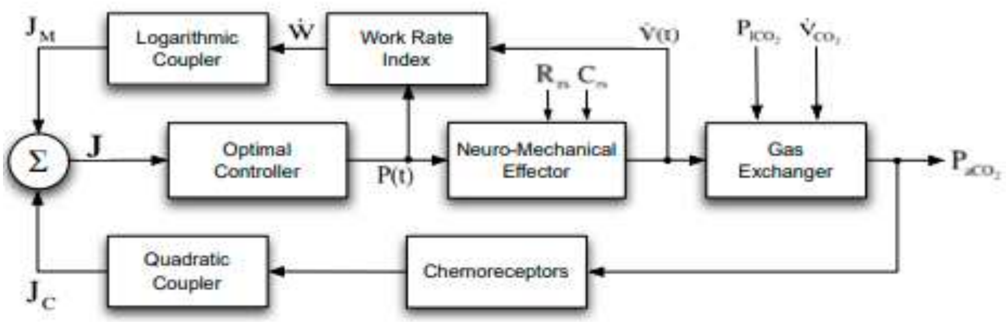


Figure 1.3. Optimal chemical-mechanical breathing control model [16]

This model was used to build a simulation framework and incorporate a human breathing control simulator on the LabVIEW platform. In the event of significant issues with signal acquisition and processing as the simulator evolves into a controller for mechanical ventilation unit, the LabVIEW platform with the available embedded systems will expend less time. The use of the simulator facilitates further study and development of the ideal chemical-mechanical air control model, the theory of the simulator.

Simulations can also be conducted subject to certain respiratory conditions as well as certain critical test conditions examined in the study, (exercise, inhaled CO_2 and charged breathing) including hypercapnia preparation, external dead space, and loaded hypercapnia and practice.

The respiratory dynamics, including airway strength and lung elastance, were described linear in the modelling for the simulator's respiratory control and implemented as 3.02cm-H_2O total lens -1 AS, 21.9-H_2O / l.

Many output indexes for improving respiratory patterns or airflow profile have been previously suggested. The inclusion of a word that refers to volume acceleration will help fine-tune the model's optimal airflow to avoid lung fracturing.

As a quadratic function, the pressure profile's inspiratory behavior was modeled in the present model. For the simulation of a mechanical ventilation system, the proposed model and simulator may be used. The overarching purpose of this research is the clinical application of the control model and the simulator to human breathing.

Al-Nagger et al. [17] the PCV pressure signal mathematical model has been developed and simulated in this article, which we combined to achieve the mechanical ventilation system simulator with the updated lung simulator. The MM is capable of representing parameters and constraints, thereby representing the internal PCV system by the simulator. The input and output signals can be tracked as constant waveforms to simulate the actual artificial ventilation mechanism. It then contributes to the use of the simulator to study the actions and variables of PCV fans in training students in laboratories. The model and simulator show that the improvement in the lung mechanic is capable of reflecting. Nevertheless, the simulator requires the extension of the modulated internal respiratory mechanic parameters.

Rozanek et al. [18] the respiratory system model which is developed by the respiratory system's anatomical structure was developed. For CV and HFV simulations, the model may be used. The model facilitates experiments on the intrapulmonary parameters of various ventilatory regimens. It is also possible to research the effect on the efficiency of ALV of improvements in mechanical properties. In the case of a different mechanical parameter of the device, the research model has used the intrapulmonary conditions. Mechanical properties of lung tissue are altered in ARDS. The transition depends on the source of ARDS. The efficacy of elementary ventilation methods can be observed with the various mechanical properties the system of air and the optimum ventilation procedure can be selected for different forms of ARDS.

Richard et al. [19] the paper presented demonstrates the ability of the xPULM simulator to imitate diverse flow patterns in daily life and the clinical environment. Two models of respiratory system breathing based on chosen models were selected for testing: a) restful human breathing b) patient with artificial ventilation. The mathematical model for the linear single compartment has shown its ability to mimic physical respiration. Measurements indicate strong reproducibility cycle-to-cycle. Inhalation flow and exhalation flow hits an average measuring period of the stable pinnacle of 50 l / min. E ratio (1:2) is also maintained as a physiological value of I. As a foundation for physical estimation in artificially-ventilated patients, the non-linear one-compartment statistical model was used. During artificial ventilation, the flow patterns are distinguished by abrupt shifts in the flow, which require high levels of the system. The measures with xPULM have a strong association with the appropriate curve and flow variation in the order of milliliters, to address these limitations. In the area of zero flow, there is also a major respiratory delay after the end of inspiration, while minor oscillations are present. To sum up, the two input signals have been repeated in an appropriate variance spectrum. It must be pointed out that sudden signal changes during artificial ventilation are contributing to high mechanical system requirements. The spinning motor speed and the inertia from the process components, in particular, contribute to minor variations the process in response. However, these variations are within a reasonable reach and do not affect the main flow performance of the simulator substantially. Further improvements would include the introduction of new air patterns, the refinement of the combined controller and motor driver settings so that evolving signals will respond much faster. In the chamber, extra negative pressure was exerted to hold the used lung counterpart inflated, even though the induced pressure differences depending on the expected breathing signaled to very swift pressure changes inside the chamber. In the event of a more complex and inert lung similar to a porcine lung, this also helps one to infer that the xPULM simulator should be used for certain fast-change feedback signals.

Noman Q. Al-Nagger et al. [20] this paper aimed at modeling and simulating VCV output signals and lung conditions during VCV mechanical ventilation. It also aimed at consistently displaying VCV signals and p-v curves. The simulator offers a monitor for the key artificial venting parameters of the VCV, using a presented simulation procedure, which makes the perfect and realistic case for an idea of the artificial venting mechanism. The simulator can also track the VCV output signals and compliance with instantaneous and continuous waveforms. The system output can be evaluated using the simulator; therefore, a good instrument for the analysis, in training laboratories, pulmonary and VCV status monitoring and definition can be used during artificial ventilation. Quadric, linear and exponential formulas are applied for merely formulating MM, with only the principal VCV signals and PEEP, but the breathing mechanism and mechanical ventilation are regulated by another critical component. This helps the submitted MM and simulator to represent further variables of the system and patient in artificial ventilation and involves more testing and validation to acquire a separate lung state fan analyzer.

Su et al. [21] a basic model and a complicated non-linear model are used in the article. The approach that can regulate the output flow is implemented. For creating the respiratory activity, two main tracks, respectively Simulink and LabVIEW, are used. For control purposes, the hybrid process, which can incorporate the benefit of the two processes, is seen. This paper described respiratory modeling and control architecture in general.

Jakub Rafl [22] in this paper by integrating a circulatory mechanism with a model of a mechanical ventilator, a practical model for the cardiopulmonary ventilation was assembled. The key focus of this study was the creation of circulatory models; two key aspects of the circulatory model are pleural pressure causing transmural blood pressure in the chest and the capillary pulmonary area affecting alveolar pressure and lung volume. While the idea of thorax extramural pressure may have been introduced in published papers, the physiologic evidence had not given an approximate function that combining lungs volume and pulmonary capillary resistance.

Circular model parameters have been updated to conformity to their fundamental variables (cardiac output, artery pressure etc.) during a random breathing assay to normal physiological values. The predicted pattern was verified by simulation of artificial ventilation: with increasing end-exhale alveolar pressure and pleural pressure, cardiac output and systemic arterial pressure decreased. The model forecast that the cardiac output will decrease by 8.4% at zero expiratory pressure. This finding is satisfactory in contrast to a 10 % reduction recorded in my literature, given the simplification of cardiopulmonary connections to two causes and the discretization of the blood circulation system to a few compartments. In comparison, the tests with high-end expiratory pressure revealed substantial results which were more than twice the size of the cardiac output in the model that was recorded in literature. In comparison to the baroreceptor absent, this can be managed either because of lung exaggeration created by a linear ventilator or because of an extreme lung resistance reaction induced by the rise in lung volume. However, the potential factors cannot be isolated because the circulatory model cannot be adequately evaluated without the fan model. The findings are in this regard incomplete.

1.3. Purpose and Scope of the Thesis

The utilization of digital twins has picked up fascination in research and practice as of late. Digital twins are virtual portrayals of physical items and they can be associated with their physical partners. Through this association, digital twins add to the assembly of the genuine and the virtual world. In the healthcare sector, the medical systems are very expensive, it was difficult to design medical systems, and it is very difficult detections fault and diagnosis and monitoring system. The digital twin is a good platform to create a digital copy for medical devices. Simply, a digital twin is a virtual model of item or administration a procedure. This matching of the virtual and physical universes permits the investigation of information and checking of frameworks to take off issues before they even happen, forestalls vacation, grow new chances and even arranged for the future by utilizing reenactments. The digital twin idea would be applied to empower electronic clinical records, customized medicines, empower collective information to be looked into and decide an effective treatment and help with diagnostics by running treatment simulations without hurting the patients. The ultimate goal is to use various current intelligent systems concepts in synchronization to aid the development of a fully functioning digital twin. It is highly achievable within the next five years. Digital twins are used in many other industries for tracking, repairing equipment and simulating future results if any issues occur while in operation. The application of healthcare will provide many benefits. From medical devices and their procedures, it will finally be possible to build a fully functioning digital twin in which clinical trials and customized treatment models can be conducted without harming patients. In this thesis development of cloud-based intelligent healthcare system using digital twin with the development of technologies, such as cloud computing, and the IoT intelligent system as the technology for precision simulation from design to implementation, the digital twin is applied to the industry.

The main focus of the thesis was the design intelligent healthcare system using the digital twin and use the cloud system. The system will be using in the healthcare sector because the healthcare systems are a very wide, the healthcare systems are very expensive and very complex, difficult to design, there is little possibility to work on the health devices. But the create a digital twin for healthcare systems it’s beneficial, and it is more advantages, for example, reduce production time, reducing costs, safe running of the production process, and effectively improve production efficiency so that it can be used for structural monitoring. Some calculations, assumptions and selections were made to take a proper and realistic design into account. In the master's thesis, a digital twin of the breathing apparatus will be made using the cloud for stored the patient's file, the purpose of this thesis is to explain as the following items:

- It is necessary to analyze in a very detailed way and understand all parameters related to the mechanical ventilator setting to creating the intelligent healthcare system.
- The planning and design of the intelligent system were done in great detail.
- Makes modeling and simulation, we can use the cloud system to store all the data from where it is collected.
- This application of this administration security area has very well because only one admin it means only doctors can look at the outputs, enter data, or they can be compared with the normal ranges, and after entering all the data they can see in a chart appeared only doctors have no other user use the applications there is no need for users else they can do this.

- In this application, an intelligent healthcare system is a network fitted with an integrated internet computer that records, analyzes and connects with other systems. the ability to draw on the know-how, protection, accessibility, adaptation to current data and ability for remote control and management are also other requirements for intelligent systems. after receiving data from the cloud system anywhere or at any time, it is included in the program and shows and graphically displays the patient's blood pressure and pulse, average oxygen level and heart rate in the human body.
- If the oxygen saturation in the human body is low, we can enter the settings of the mechanical ventilator and enter all the input parameters and see all the output parameters of the data as a report and see it graphically, shows as a message about the patient's state explain how much oxygen she/he needs.

1.4. Structure of the Thesis

The parts of the master thesis are arranged as follows:

Chapter 1: In this chapter is the introduction to this thesis and provides a summary of the background of this thesis. The digital twin is very clearly defined, describes in great detail, and the healthcare sector describe all parts need to develop the digital twin, they explain all digital twin in the literature reviews, also, the describe purpose and scope of the thesis, the definition of the assignment and the research organization is also given.

Chapter 2: In this chapter explains the digital twin, the features of digital twin implementation steps are explained and describe the digital twin application review, for this study, descriptions of software and hardware technologies that can be used to create digital twin studies are summarized in great detail.

Chapter 3: In this chapter describes the cloud-based intelligent healthcare system using digital twins and some information about this subject and recommendation approach, and then creating the digital twin for an intelligent healthcare system such as mechanical ventilator appears how to create is describing all steps are very clear and very detailed, also explaining all basic parameters of mechanical ventilator setting ware very detailed and explain all equation for each parameter.

Chapter 4: In this chapter discusses the material and method we followed in our work, the requirements of the recommended method are explained, and the components for each method are described.

Chapter 5: In this chapter contains some information about the results and discussions and technologies used for implementation; identify all technologies used to create advertising digital twin for mechanical ventilator using cloud system and artificial intelligence, have data on evaluating results after producing simulation results; explain the result of the assessment, if the patient is male or female, there are three cases for each patient.

Chapter 6: In this chapter comprises the research conclusions, includes references used in this research, and include appendices used in the thesis.

2. DIGITAL TWIN

This study aims to define the concept of digital twin and its benefits to the healthcare system sector. The sectors using the digital twin concept are examined with a focus on the intelligent system. Known as one of the most important developments in engineering is argued. Also; the issue of how to create a digital twin for the building sector is also examined.

The digital twin is considered to be one of the key trends in IoT. The concept of a digital twin is to create a real object's digital copy and use the mirror as the focal point of visual contact. A digital twin may be a factory lathe, a windmill, a container ship or a vehicle. In 2018 the Gartner group listed digital twins as one of the top 10 technology trends. A Gartner study showed about half of companies are using or intending to use digital twins in 2018. The utilization of digital twins has picked up fascination in research and practice as of late. Digital twins are virtual portrayals of physical items and they can be associated with their physical partners. Through this association, digital twins add to the combination of the genuine and the virtual world.

A digital twin is a simulated image of a physical body that uses data in real-time for understanding and analysis during its life cycle [23]. It can generally be defined as the relation between the real world and the virtual world. According to the first references published about this subject of literature, there are three specific criteria for the development of a digital twin: a real entity in the real world, a virtual entity in the virtual world, and a connection between the real world and the virtual world [24].

The definition of the digital twin, originally found in the fields of product development and product life cycle management, has been used in studies in numerous fields such as astronomy and aviation [25]. NASA has been reported to be interested in ecological space exploration [26]. It can be used in many different sectors, such as oil, automobile, healthcare, manufacturing and the military. It is especially important and beneficial to be used in industries with high-cost processes. Several copies have been developed and displayed on different platforms for the testing of industrial goods such as aircraft engines; wind turbine, high budget, and even the shortest downtime caused great loss of money and energy.

The intention of creating and using digital twin; the physical object, in other words, the actual thing, to keep an eye on the whole of life, to keep an eye on his career, to search and to respond to a variety of needs, such as the right to work. Potential improvements that may be evaluated in a simulated world before the real object is used [24]. Any improvements can be considered different worlds and interactive experiments created and depicted. Mainly remaining in people's heads, actively introducing an increasing variety of interest can be an expensive method of complexity. The structures in mind can be tracked by constructing several settings with specific criteria. A digital twin can run in real-time and connect with the user object at each point and provide the required information. Not a static structure that can be coordinated at any point, living is a dynamic process. Revealed at the beginning of the early stage, the concept takes form at the point of manufacturing, the business evolves, and the cycle is eventually completed.

Considering the virtual item physical article basic the digital twin idea and the association between them, it can be said that a building's digital twin must come to life as the construction project starts to find an answer in the real world. For the digital twin, data collection can start from the point where construction development begins. Conceptually, this cycle can be associated with the initiation of the actual development of the building project, or from a particular point of view, at the construction site where construction operations are carried out, in the below Table 2.1 describes all digital twin basic interpretation of scientific literature.

Table 2.1. Describes digital twin basic interpretation of scientific literature

Authors	Definitions
Tao et al. (2018, p.2) [27]	"Total DT (Digital Twin) will include five parts: virtual part, the physical part, data, connection and service."
Autiosalo. (2018, p. 243) [28]	"Part of the Cyber-Physical System is a digital twin."
Demkovich et al. (2018, p. 295) [29]	"A digital twin of the development system reflects the device, processes and services in the operating framework of a multi-level graphic architecture., i.e., enabling the simulation of the processes taking place in the actual system, as well as the compilation and display in actual-time of data on the state of items collected from the PLC and sensors mounted in the production system on both the physical system."
Kritzinger et al. (2018, p.1017) [30]	"A particular interpretation of digital twins is defined as a digital equivalent for physical objects based in all senses on the specific meaning of a digital twin."
Zheng et al. (2018, p. 2) [31]	"In a broad sense, DT is an integrated system capable of simulating, adjusting, calculating, monitoring, and controlling system status and processes."
Michael Grieves et al. (2017, p. 94) [32]	"The digital twin is a set of graphical information systems that depict an entity from the micro-atomic to the macro-geometric phases, whether future or current, digital twin (DT). Some knowledge that may be gained by observing a physically produced device from its virtual mirror will be accessed at its peak."
Negri et al. (2017, p. 946) [33]	"The DT (Digital Twin) consists of a simulated version of a production system capable of operating on various simulation disciplines distinguished by the coordination between the simulated and the actual world, thanks to sensed data and linked smart devices, mathematical models and real-time data elaboration."
Boschert, Rosen et al. (2016, p. 59) [34]	"The concept of the digital twin itself refers to a detailed physical and practical definition of a part, device or program that provides more or less all the details that may be useful in all phases of the present and future life cycles."
Michael Grieves (2014, p.1) [35]	"The digital twin design model includes three key parts: a) physical objects in real space, b) virtual items in virtual space, and c) data and information relations that tie together the virtual and actual objects."
Edward Glaessgen et al. (2012, p. 7) [36]	"An immersive, multi-scale, probabilistic simulation of an as-built vehicle is a digital twin or device using the latest physical models available, sensor upgrades, history of the fleet, etc., to reflect the life of its comparing flying twin. The digital twin is ultra-real, one or more significant ones and vehicle systems interdependent including airframe, energy and propulsion storage, support of life, avionics, thermal protection, etc."

Digital twin Characteristics: Digital twins possess many features; this part describes the characteristics of a digital twin

Unique identifier: Each digital twin will have a unique identifier to interact with his or her twin.

Sensors and actuators: Actual twins could be fitted with sensors so that digital twins could mimic them.

Senses sight, taste, touch and smell and hearing using the correct actuators, depending on the application requires.

AI: To make fast and intelligent decisions on behalf of their real twin, digital twins should be fitted with a controller embedded with ontologies, machine learning and deep learning techniques.

Communication: Digital twins should be able to communicate with the world; actual twins and/or other digital twins in near real-time as shown in Figure 2.1. Communication /interaction between digital and real twins [37] Contact, including touch sensation (haptics), must take place within 1ms, and must, therefore, meet the 5G and Tactile Internet requirements.

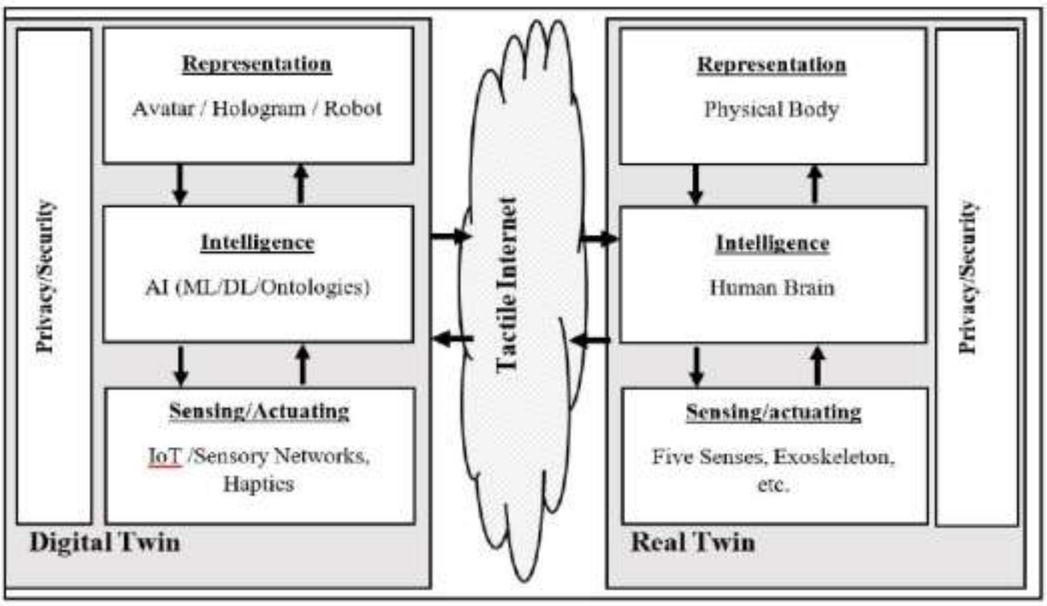


Figure 2.1. Communication /interaction between digital and real twins [37]

Representation: Digital twins may have a visual representation as a hologram, even a humanoid interactive, or a 3D avatar robot but they could also be elements of a software lacking any physical representation, depending on the specification.

Trust: For digital twins to perform important activities, such as handling bank transfers or engaging in meetings on behalf of the real twin, real twins must be prepared to trust their digital twin, such as an investment account for their real twin.

Privacy and security: Digital twins need to be able to protect their true twin's identities and privacy. This will include the use of sophisticated cryptography algorithms and biometrics (ECG biometrics, haptic biometrics, so on) and also because of the resolution of political issues and regulatory.

2.1. Digital Twin Implementation Steps

The phases of the digital twin, to create a digital twin for the real object or any physical devices, it takes some stage. Figure 2.2 below describes the main stages of a digital twin.

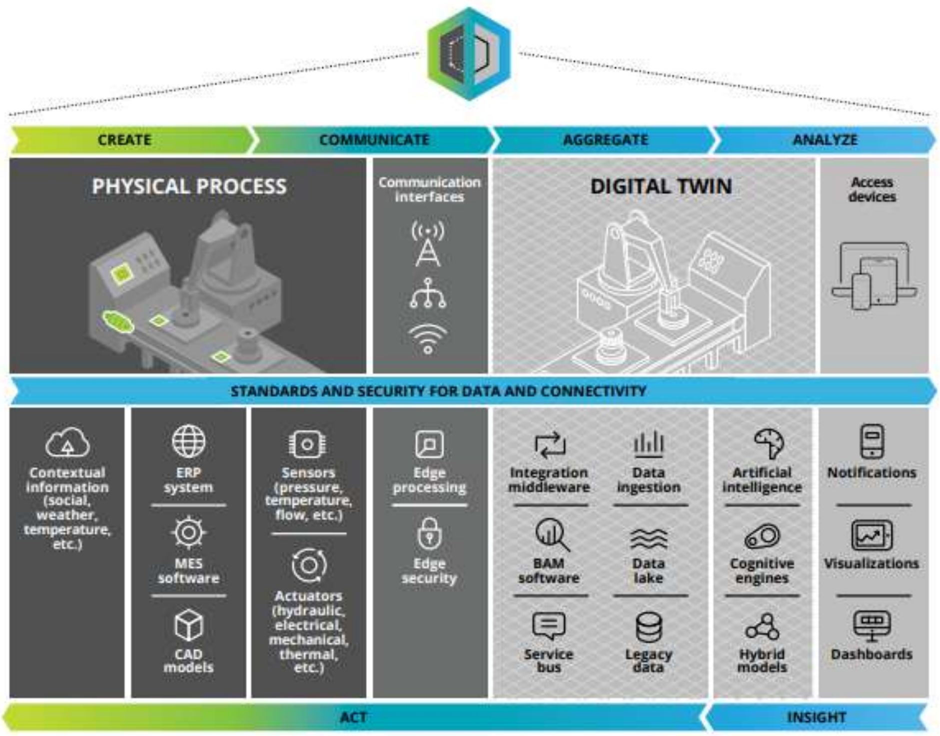


Figure 2.2. The phases of digital twin [38]

Create: The creating stage involves the adaptation of the physical process to countless sensors that quantify vital inputs from and around the physical process. Sensor measurements can be usually separated into two categories: (1) operating metrics relating to the productive asset's physical efficiency parameters such as tensile power, shift, torque and color uniformity (including several works in progress), (2) environmental or external data, such as atmospheric temperature, barometric pressure and moisture levels, influencing the functions of the physical asset. Messages may be encoded utilizing encoders into protected digital messages and sent to the digital twin. Method related data from applications such as distribution systems, business resource planning, CAD models and supply chains systems will improve the sensor signals. The Sensors' signals can be improved. The digital twin will then have a wide variety of data constantly modified to be used to evaluate it [38].

Communicate: This communication phase aims to merge the physical mechanism and the digital platform smoothly, in real-time and two-way. Radical improvements that have allowed the digital twin have been made to the network connectivity, and it has three key components: Communication interfaces, Edge processing, Edge security [38].

Aggregate: The aggregate stage will help data ingestion, processing and analysis into a data repository. The collection and retrieval of data may be performed on-premise or in the cloud. Over the past few years, the technical realms of power data aggregation and analysis have shifted enormously such that programmers can produce increasingly efficient and more cost-competitive, massively scalable architectures [38].

Analyze: Data is processed and viewed in the research process. To build iterative models that create observations and feedback and influencing decision-making, data scientists and analysts may use advanced analytics tools and technologies [38].

Insight: The insight into the process gives insight from analytics through the visualization panels, lights in acceptable differences in the output of the digital twin model in one or more dimensions, hence the physical world analog, that indicates areas that are undoubtedly needed to be examined and modified [38].

Act: The action phase is to provide the physical assets and digital process with actionable lessons from previous phases, to achieve the effect of the digital double. Insight is passed to decoders and is then conveyed to the actuators in the asset process which are responsible for movement or control mechanisms or are upgraded to backend structures that control supply chains and order actions, both subject to human intervention. The closed-loop relationship between the physical world and the digital twin is completed through this connection [38].

2.2. Digital Twin Applications Review

Digital twin simulations of data scientists and IT professionals before real devices are created and deployed are virtual copies of physical devices that can be used to run. Also, how technologies like IoT and artificial intelligence are optimized although it is also changing;

Necessary considerations for the application of digital twins. If you think your application digital twins on your business, there are several important things to keep in mind:

► Linked products, not only from engineering or operational terms, as 'product' to meet the needs of the person responsible for devising and operating, as well as require a digital twin extends the product life.

► You need analysis at every stage of the life cycle to make improvements throughout the system.

► Digital twins require deep industry expertise and knowledge in functional areas when considered in the context of the industry.

It is a predictable fact that digital twins will occupy an important area in our life in the future.

Digital twins "living" models ensure the execution of business results. The digital twin can simply be described as a virtual presentation of a physical production system. In other words, it can be called a virtual copy of a processor line modeled to behave as real. It is possible to evaluate this technology from start to finish, from the design of the production line to the production plan and schedule on that line. According to Michael Grieves, the author of the book, Product Life Cycle Management, which is one of the first names that use the term for the first time, three factors are required for the digital twin. Sensors are needed to establish the connection. It connects to PLCs and sensors that manage the production system and collects real-life data and sends it to its digital twin. In this way, with the interaction provided, improvements in production performance are provided.

► Process planning in digital twin: Digital twin technology improves collaboration between design and manufacturing employees to better plan how to determine what to do and how and where to do it.

► Arrangement: With the layout of the production division, it is recommended that the digital twin be created in all mechanical, automation and resource details and inextricably linked to the product design and manufacturing ecosystem. Using a combination of product lifecycle tools, you can easily move to cells, equipment and personnel and simulate operations.

► Process Verification: Digital twin can be used in this phase to verify assembly processes.

► Efficiency optimization: Digital twin is also used to access and statistically simulate your planned production system. Digital twin; it also helps you to assess whether you need to use manpower, robots, or a combination of the two.

2.3. Software and Hardware Technologies for Digital Twin

In this part describe all software related to creating the digital twin and using many technologies for creating a digital copy for medical systems.

2.3.1. Software that can be used for Digital Twin Studies

Digital twin software provides a virtual representation or simulation of a physical asset and is used in real-time monitoring of the asset performance. Simulating performance, predicting potential maintenance needs and ultimately optimizing the asset for peak performance are using these tools. Businesses use sensors to embed their physical assets to generate the data needed to notify a digital twin. We can track and control the physical part of the machinery by turning the properties into IoT enabled devices. Together with IoT device management software or Computer-Aided Engineering (CAE) applications, such devices are often used [39]. To qualify for inclusion within the digital twin class, a product must: Provide a digital illustration of physical quality, track knowledge created by the physical quality via sensors, allow users to optimize the performance of the physical quality supported the information created by the asset [40], in the following Figure 2.3 shows various tools for digital twin modeling.

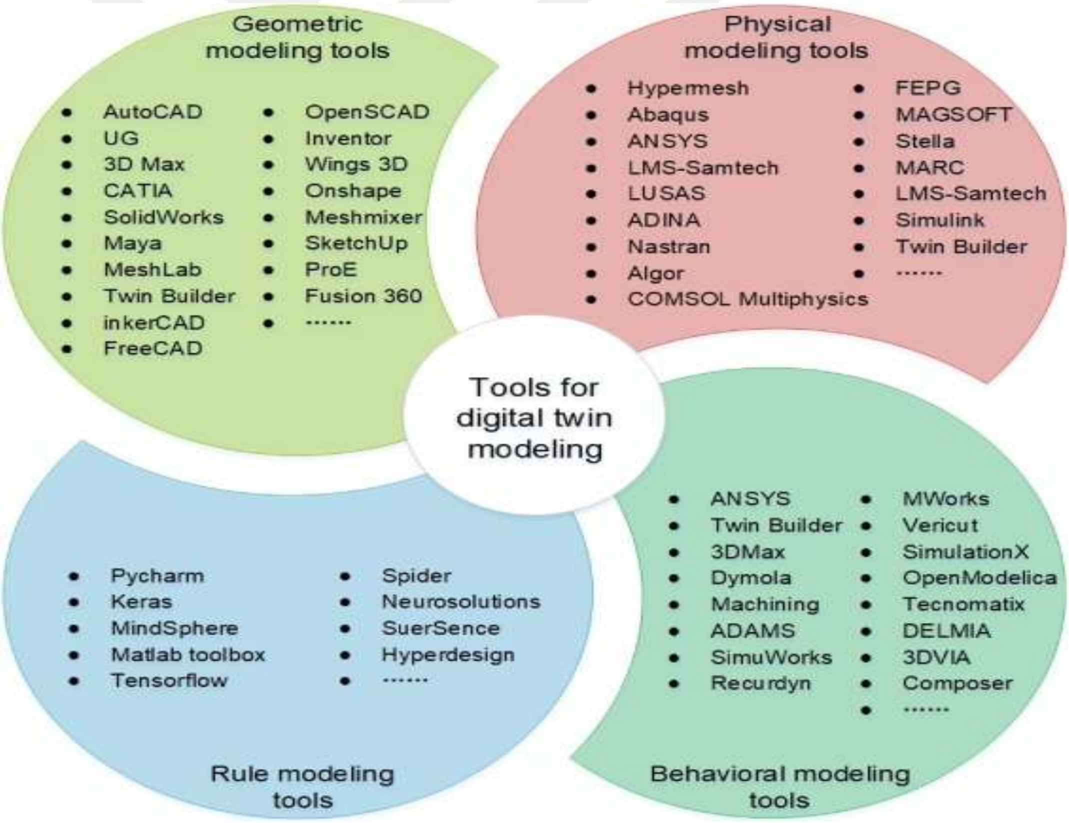


Figure 2.3. Tools for digital twin modeling [40]

In the following Table 2.2, describes all the programs used in the scientific literature to create a digital twin.

Table 2.2. The name and description of all software

Software	Short Description	Reference
MATLAB/Simulink	"MATLAB is a software package for computation and simulation and a programming language of the fourth generation, released by MathWorks. It manipulates matrices, maps variables, algorithms and several high-level mathematical operations. His accompanying package is used in multi-domain graphics emulation. Simulink."	[41]
SIMPACK	"SIMPACK is a multi-body simulation (MBS) software tool that facilitates the creation of any mechanical or mechatronic structure, spanning from small parts to full structures (e.g., wind turbines, cars and high-performance Formula 1 engine)."	[41]
Abaqus or ANSYS	"ANSYS is a computer simulation software service. It is a program that applies the principle of finite elements to solve previously distinct equations. Yet ABAQUS offers the best, nonlinear, transparent and complex approaches for linear problems."	[41]
Unreal Engine	"Unreal Engine is a game development engine that is free to use and developed by Epic Games. It can be used to build a wide range of game styles from 3D, 2D, and VR. The interface is known for its outstanding features in visuals and illumination. It also contains a collection of resources, items, and characters. In addition to supporting coding languages, Unreal Engine features a graphic interface, named blueprints, to build game rules that do not include coding expertise."	[42]
Unity3D	"Unity3D can be a versatile 3D engine cross-platform and a user-friendly environment for development. Unity should be of interest to anybody who wants to simply create 3D games and apps for smartphone, tablet, online, and consoles. Unity should be easy enough for the novice and strong enough for the professional."	[42]
AutoCAD	"AutoCAD software supports complete 3D functionality which requires modeling of objects such as applying textures and illumination. AutoCAD employs network license management, enabling you to distribute multiple versions of the program with a large user community, and for details such as content measurements and proportions you can link it to other repositories. AutoCAD provides design models, called DWS files, which require drafters to conform to common drawing specifications such as ANSI and ISO and have preset text types, title lines, dimensional designs and layouts."	[42]
Fedem	"The company: Fedem is a technology company specialized in advanced engineering study and consultancy, as well as construction tools for multibody dynamic modeling and lifetime measurement of buildings and mechanical systems under the effect of complicated loads."	[43]

CAD software	“The software method of CAD (Computer-aided design) is used for the forming of accuracy sketches or scientific diagrams by architects, engineers, authors or artists. Two-dimensional (2D) drawings or three-dimensional (3D) models can be generated using the CAD kit.”	[44]
3D modeling	“3D software is a category of computer graphics software that allows 3D graphics and animations to be created, generated and produced. 3D software allows users to imagine, plan and manipulate a three-dimensional entity, world or graphical feature. 3D software provides applications and animation kits for computer-aided design (CAD).”	[45]
Java	“Java is a language of programming that creates multi-platform applications. The compiled code (known as byte code) works on most operating systems, including Windows, Linux, and Mac OS, when a programmer creates a Java script. Java draws much of its vocabulary from the programming languages of C and C++.”	[46]
3D Max	“3Ds Max is a 3D layout, motion and digital image computer graphics software. It is one of the computer graphics industry's most popular programs and is well known for having a comprehensive 3D artist’s tool kit.”	[40]
Twin Cad	“The Twin CAT computing framework transforms virtually every PC-based system into a real-time control with some PLC, NC, CNC and/or robotic run-time systems. Twin CAT 3 is Twin CAT 2's structural change that redefines the automation technology industry.”	[40]
GE Prefix	“Software representation of physical assets, comprehensive software platform for digital twin, to provide overall solutions for IoT service (Operational technology).”	[47]
Eclipse Ditto	“The way to simplify IoT solution deployments, open-source (free) & easy to extend, define basic protocol (minimum requirements).”	[47]
IBM Watson IoT	“Virtual representation of physical assets, a comprehensive management platform for IoT solution, to provide overall solutions for IoT service (Operational technology).”	[47]

2.3.2. Enabling Technologies for Digital Twin Studies

When there is a data flow between an existing physical object and a digital object and they are fully integrated into both directions, this is an indication of the "Digital Twin", a modification made to a real object affects the digital object immediately, and vice versa. In the following Figure 2.4 describe the digital twin concept.

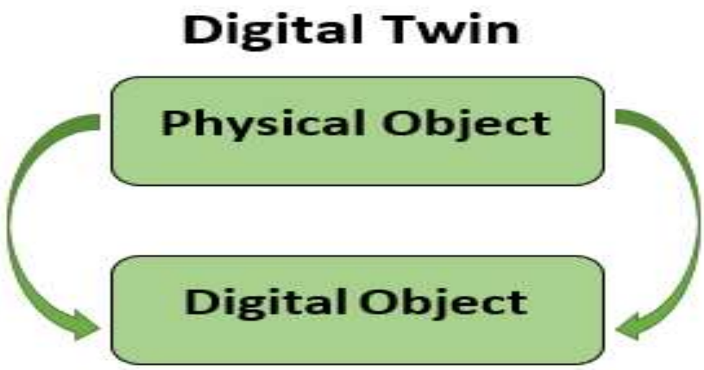


Figure 2.4. The digital twin

It will continue with the future applications for digital twins, with a review on the field, sectors and particular issues in digital twin technology. For the moment, the word and meaning of a digital twin is growth in academia and developments in IoT and artificial intelligence helps this progress to improve.

This part deals with allowing digital twins technologies, the realization of these digital twins would need the help of a range of main technologies:

Data Analytics: The term data analytics is a paragliding term for grouping analytical concepts seen in the paper and academia. Therefore, a comprehension and review of certain articles are important. The word data analytics comes from the field of “Data Science" a multidisciplinary discipline that encompasses a variety of topics, with a focus on gathering and presenting data for analysis to obtain greater insight. The be Low subsection provides an in-depth overview of the data analysis area [48].

Artificial Intelligence: The type and role of digital twins will help enhance teaching, operations and results through artificial intelligence technology such as augmented reality and virtual reality interfaces, the first area of interest in data analytics are artificial intelligence. The overall description of AI dates back to the late 50s when this notion of "intelligent systems" was created [49]. IoT data is analyzed using algorithms that are continuously developed with the user data modified. Using these data from the time series, a digital twin of a user may recommend acts to monitor or prevent potentially harmful circumstances, digitalization and emerging technology like digital twins and artificial intelligence help manufacturing companies to achieve exponential speed, performance, consistency and versatility.

Machine Learning: Machine learning, a subsection of AI, is the creation of algorithms that can allow the computer to learn and work for the user without being directly programmed to do so. Machine learning is used to construct systems that autonomously gather and process knowledge using advanced algorithms [49].

Supervised Learning: This is the most common way of learning machines. To evaluate and understand large quantities of the data, the algorithms use. The algorithm is designed to accurately classify a particular task by observing and analyzing the labeled data; image classification is one instance [50]. The algorithms are learned from the training data and then checked to see how accurate a picture through a percentage age is to determine exactly what it displays. The user then analyzes the responses and corrects and relearns any mistakes and helps to train the model and to improve the exactness of a certain algorithm [51].

Unsupervised Learning: In the case of an unregulated learning algorithm, a supervised learning algorithm collects large quantities of data. Simply because it's not the duty of the algorithm to evaluate user entry. Unsupervised learning algorithms train on their ways to categorize and highlight trends in data instead of using input from users. One way of categorizing data is to cluster. Algorithms may be trained in the selection of unlabeled data sets, which may reveal hidden patterns that cannot be defined explicitly [50].

Deep learning: Another section on data analytics and machine learning is deep learning. In comparison to manual extraction, deep learning algorithms are learning unstructured and unlabeled data through complex neural networks with autonomous extraction [40]. Such networks use machine learning to build deeper learning algorithms which can take time to train, but which require greater accuracy. Semi-supervised learning, which is described as having some data labels, is often used to learn how the algorithms can be improved [52]. More data is unlabeled.

Cloud-Computing: The cloud is the Internet – it is just stuff that you can remotely control over the internet, more precisely. It means if everything is on the cloud, rather than on the hard disk of your computer, that it is saved on Internet servers, cloud-based systems eliminate this obstacle and bring stability to data, which adds protection, where data is becoming the most precious commodity of the enterprise. This means that businesses would be able to take new technologies lower cost, higher profitability and quicker market times, the cloud allows integrated data consistency by definition; digital twin institutionalizes business information in the face of a challenge and guarantees continuity in the event of a critical failure, be it person or content.

Public cloud-based cooperation brings security risks and protection has been integrated into the code by good networks. "This is a crucial differentiator for the 3D EXPERIENCE cloud network, according to Mysore. “Dassault Systèmes” definition of “deep security” is based on the proven presence of many separate frameworks to minimize risks and adopt, where practical and applicable, industry guidelines and best practices. The platform has robust access controls and verification, including two-factor authentication, when it comes to the security of users. And all communications are carried out with a protected 128-bit encryption transportation layer socket layer”. The migration of computation and control to cloud computing infrastructures will make digital twins more flexible and ensure they are still ready to support their true twin [53].

Wearable: Wearable technology attracts a lot of consumers. The vast amount of physiological data obtained daily by these tools could be used by digital twins to help their actual twins more effectively [53].

IoT: The Internet of Things is the word used for internet-related devices. Its considerations offer a sense of intellect and the capacity to gather knowledge about their world about what are known as "things." The word first emerged at the end of the nineties with Kevin Ashton outlining his IoT vision. The notion that all integrated devices allow the creator to track and control everything that we do, leading to a more intelligent environment.

As shown in Figure 2.5 allows imagining a completely interconnected universe by the vast number of computers attached. This concept of utilities related by IoT is demonstrated. IoT devises expansion is universally positive and impacts the heart of everyday living, communicators, healthcare, architecture and transit, intelligent communities and manufactures, contextual data could be fed by users via the IoT to their digital counterpart, and input could be transmitted to the environment, helping users to communicate more seamlessly with their environments and remote locations [53].

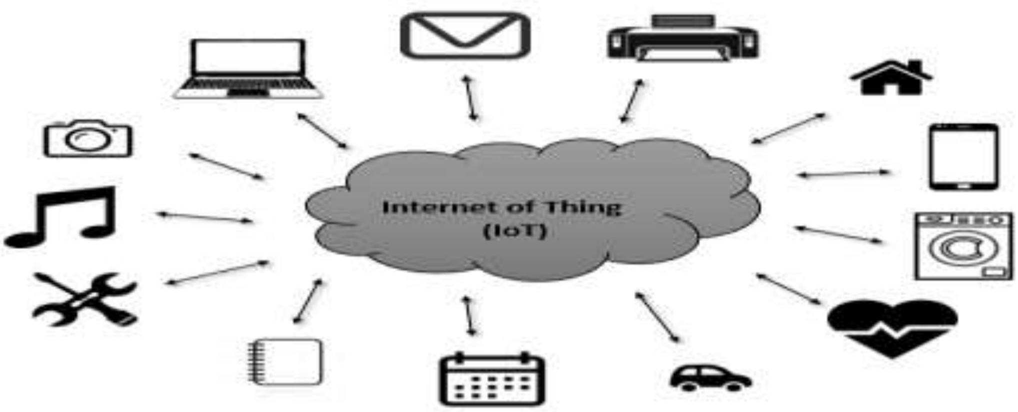


Figure 2.5. Internet of Thing (IoT) diagram

Augmented, virtual, and mixed reality: With 3D technology, digital twins could be created and viewed as a hologram or using AR / VR / MR devices (for example, Microsoft HoloLens). For instance, if a person is at work and his daughter gets sick at home, he can use sensors installed in his office to generate his digital twin in real-time and appear as a hologram to console her in front of his daughter. People may thus communicate in different locations as if they were in the same space [53].

Haptics: Thanks to the incorporation of haptic properties, digital twins may enhance communication. For instance, if Ahmad shakes hands with Lara's digital twin, the digital twin might provide Lara with the proper haptic feedback [53].

Robotics: In order to physically make digital twin works on behalf of their actual twin, humanoid as well as soft robotics technologies may be leveraged [53].

5G and Tactile Internet: The emergence of the 5G and tactile Internet, aimed at delivering ultra-low delay and ultra-highly efficient communications, has facilitated a paradigm shift from conventional content-oriented to control-oriented communication, particularly in loop applications for highly delay-sensitive people who need close integration of communication and control mechanisms. Digital twins will have a twin feedback loop that will also be active which will improve the reliability of the actual interface operation [53].

2.4. The Digital Twin Application

In most sectors, digital twin applications have been used to change how organizations work. Digital twin technology facilitates proactive maintenance requirements, decreased running expense and downtime for equipment and increased total operating performance with IoT sensors, AI-powered analytics. Digital Twin also allows "what if" situations to be measured against company goals, allowing for the most accurate decision making. Digital twin idea is the next big thing in most business sectors that assists by evaluating their virtual equivalents to accurately predict the current state and potential of physical assets. Organizations will gain better insights into product success by introducing digital twins, optimize customer service, and make better organizational and strategic decisions based on these insights. The below Figure 2.6 has all the part of digital twin applications; we continued to see digital twin big implementations in the following fields:

Figure 2.6. Different application fields of digital twin [40]

Healthcare: Digital twins at the aspect info from IoT will play a key half at intervals the healthcare sector from taken a toll reserve funds to quiet checking, preventative repairs and giving customized healthcare [54]. Similarly, for digital twin applications for manufacturing and intelligent city and wellbeing concept. In terms of health care, the advancement and progress technology are never before seen when the unthinkable becomes feasible as soon as possible. On the IoT front of the devices, networking is more affordable and simpler to introduce. [55][56]. Increased connectivity only increases the potential use of digital twins use within the healthcare sector. One technology of the future was a human digital twin which would study the body in real-time. A digital twin used for simulating the effects of certain medications is a more practical current application. Another application involves the use of a digital twin for the planning and execution of surgical interventions [57]. Likewise, the use of a digital twin provides researchers, physicians, hospitals or healthcare providers and other applications within a health care system the opportunity to model environments which represent their needs either in real-time or in pursuit of potential technologies and usages. Also, the digital twin can be used to make cleverer predictions and decisions simultaneously with AI algorithms. Just as many applications within healthcare do not directly include the patient but are beneficial for the ongoing care and treatment. Digital twin for healthcare is in its infancy, but the scope is huge from being used for bed management to big-scale hospitals and hospital administration. It is much more important for healthcare because we should model and function in real-time since it could vary from life to death. In addition, the digital twin will help the prognostic maintenance of medical equipment and the latest repair. The digital twin inside the medical surroundings has the potential at the side of AI to form life-saving choices supported period and historical information, discussing current research within a healthcare setting

[58][59]. Many implementations of a digital twin have been listed here, showing some of the overlap in the intended use, which demonstrates how predictive maintenance from manufacturing facility-based machinery can be applied to other implementations and how digital twin is unique to their intended use. The AI, IoT and Industry 4.0 advances have made it possible for the digital twin to develop.

Manufacturing: Digital twin is balanced to change this confront of the fabricating division. Digital twins have a motivating impact on the method things are planned created and well-kept. It makes producing additional productive and optimized whereas modification output times, digital twins can span a greater range of assets in other sectors such as the digital twin of an engineering facility as both tracking and device operation is well defined as more sensors are complete (more sensors) physics-based models [54].

Automobile: Digital twins will be used at intervals the vehicle phase for creating the virtual show of associate in a nursing associated vehicle. It captures the activity and operational data of the vehicle and makes a distinction in analyzing the normal vehicle execution moreover because of the associated highlights. It too makes a distinction in transfer a personalized/ bespoken profit for the clients [54].

Smart Cities: The smart city composing and usage with digital twins and IoT info makes a distinction up economic advancement, productive administration of assets, decrease of environmental footprint and increment the general quality of a citizen’s life. The digital twin demonstrates can give help city organizers and policymakers among the smart city planning by discovering the experiences from completely different sensor networks and intelligent systems. The information from the digital twins provides help them in inward at wise choices for the long term additionally [54], a digital twin can be used to capture the spatial and temporal effects to maximize urban sustainable growth. 'Virtual Singapore' is the first digital twin in the world to deliver an efficient way for singaporeans to participate in the digital sector, for example, as part of the singapore smart Nation initiative.

Digital singapore is an interactive 3D city model and shared data portal, like singapore's 3D maps. Once done, virtual singapore is the esteemed 3D multimedia portal for public, commercial, human and science use.

Retail: The retail industry is crucial to attracting consumer expertise. Increasing retail consumer expertise by rendering interactive twins for consumers and designing templates for them plays a key part in digital double deployment. Digital twins also help to design more stores, and to incorporate security associates optimized nursing energy management [54].

Industrial IoT: Industrial companies with digital twin implementation will currently monitor, track and management industrial systems digitally. Excluding the operational knowledge, the digital twins capture environmental knowledge like location, configuration, monetary models etc. that helps in predicting the long run operations and anomalies [54].

Automotive and Aerospace: In the automotive and aerospace industries, optical twin applications are commonly used. In automotive engineering and customization of the build, digital twins have been used but also for large aircraft and aircraft servicing. The most popular examples of digital twin application in aerospace are weight control and aircraft tracking, exact weather conditions stipulation and vehicle fault identification [60].

Agriculture: In agriculture, we are still waiting for the ability to develop understanding and tracking enough to enable detailed digital surrogates, a subset of the real-world thing is sufficiently realistically tracked and modelled that the live notification has real significance regarding the system's state. These digital twins, however, have a narrow scope: Only the digital twin for a cow can be consulted on particular aspects of its wellbeing and not, for example, on its antibody levels. digital twin’s beginnings are now emerging, remote tracking and simulation of facets of animal health are enabled by livestock monitors. Land information systems report on the state of fields and crops to advise the decisions of management. Remote control of agricultural equipment such as tractors helps faults to be detected or even pre-empted [47].

3. CLOUD-BASED INTELLIGENT HEALTHCARE SYSTEM USING DIGITAL TWIN

3.1. Introduction

The research focuses on creating the digital twin for intelligent healthcare system using a cloud system, in the following Figure 3.1, shows all the details about this application.

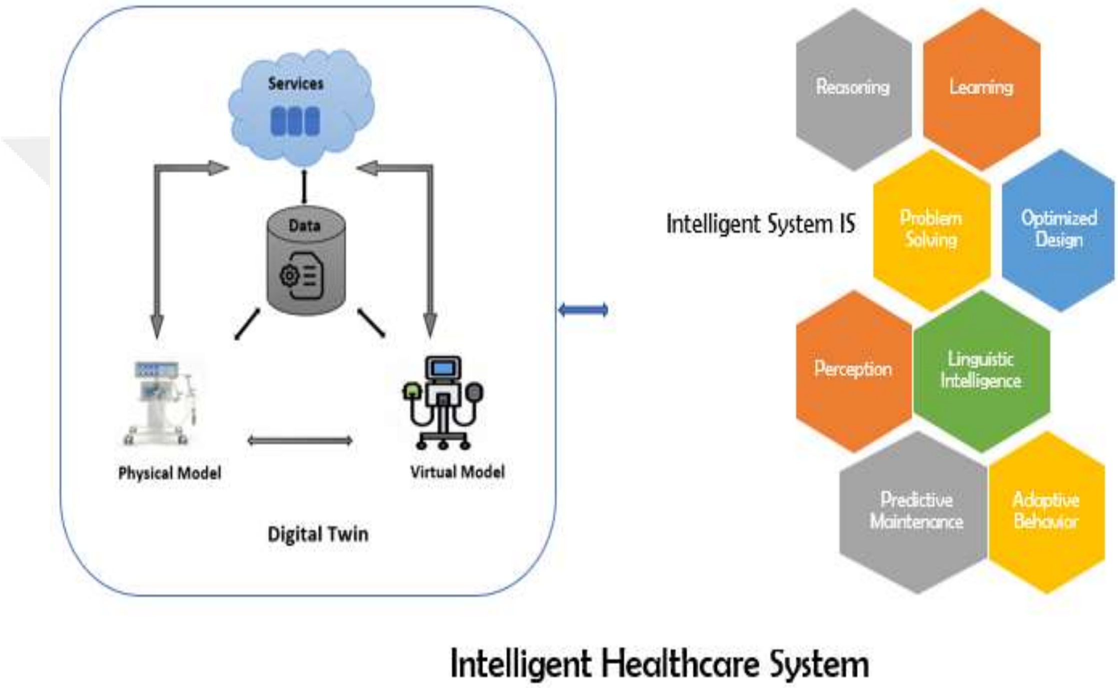


Figure 3.1. The main concept for breathing apparatus application

According to the concept, the intelligent healthcare system includes three main units: Patient information, all parameters related to breathing apparatus, and processes. All data from these units are inherited to building model the digital twin and decision support system with the use of an intelligent system.

The digital twin data technology enables the recognition of the information needed that can be understood and used in the management of the organization to help decision-making. Create a digital twin for breathing apparatus using the cloud system to storages all data about patients and artificial intelligence. The first advantage of a digital twin is the capacity to generate simulated information. An infinite number of repetitions and scenarios can go through a virtual world. To train the artificial intelligence model, the simulated data generated can then be used.

Intelligent health is applications and services that aim to increase the quality of life, improve healthcare services, increase the awareness of individuals about their health, and enable an intelligent analysis of health data. intelligent systems, with its more correct definition, is the internet of things, and the autonomous control of autonomous devices that can connect and communicate with each other over the internet, again from a center.

In it, a structure has a general-purpose concept of a set of linked entities or elements. Although the intelligent grid usually talks to computers, it not only contains intelligent devices but also integrated arrays of those devices, including networks and other large-scale structures. Sophisticated information systems based on AI, such as chatbots, expert systems and other forms of software can also be used in intelligent systems.

Essentially, an intelligent device is something that requires a computer with internet access usable but not typically general purpose. An embedded machine can be efficient and able to process and interpret data complexly, but it is typically customized to host-related tasks.

The field of intelligent systems also focuses on how they interact in changing and dynamic physical and social environments with human users. Intelligent systems will play an increasing role in society today, for example, medical care, field and service robotics, education, factory automation, intelligent transportation, human identification using various biometric modalities e.g., face, fingerprint, iris, hand, etc.

Intelligence system is used by application developers as a way to speed up design procedures, helping engineers to test multiple potential design alternatives easily. Digital twin modeling software providers contend that engineers could easily determine potential best fits based on the effects of the algorithms by adjusting design parameters and running artificial intelligence algorithms.

Description of artificial mechanical ventilation: An automatic machine is a mechanical ventilator that provides all or part of a job that the body must do to carry the gas into and out of the lungs. The process of moving air into and out of the lungs is called respiration, or ventilation in more formal terms. A type of life support is mechanical ventilation. A mechanical one the ventilator is a system that takes over the function of respiration. When a person can't breathe sufficiently on their own. A ventilator, respirator, or ventilator is also called a mechanical ventilator (machine for breathing). There are many reasons why a patient is allowed to a ventilator is required, but low oxygen levels or extreme shortages are necessary. Breathing from an infection such as pneumonia is the most common popular reasons [61].

An artificial mechanical ventilator is a treatment procedure developed to assist a person when normal ventilation is not functioning correctly to facilitate safe breathing. By extracting extra carbon dioxide from the bloodstream and bringing oxygen into the lungs, a ventilator increases the gas exchange rate of patients, thereby ensuring easier breathing. When a patient is drugged to paralyze organs, or when a patient lacks responsibility for breathing, it is often used during surgery. Although it was not commonly practiced in the 1850s, the principle of artificial ventilation came into being. Nowadays an artificial ventilation system has evolved in many ways with the advancement of technologies, medical services and the implementation of new techniques in the control system. Today, an artificial mechanical ventilator will also monitor the health of the patient and control the parameters automatically based on the needs of the patient. Ventilators are set to pump air into the lungs a certain number of times per minute. The patient's heart rate, respiratory rate, and blood pressure and pulse pressure and oxygen saturation are monitored constantly.

Description of breathing mechanism: The artificial ventilation system consists of a repeated filling and evacuating behavior of both the lungs, which is accomplished through careful monitoring of the artificial mechanical ventilator following the ventilation cycle. The respiratory cycle consists of an inspiration phase, an expiration phase, and a pause phase. The expiratory muscles are at rest during the resting process, the diaphragm does not contract, air does not penetrate or escape, and the three chest diameters are located anatomically. The pressure inside the lungs would be equal to the atmospheric pressure in the anatomical location, with a contraction of the diaphragm and all the inspiratory muscles, the inspiration process begins and an increase in the three chest diameters happens in such a way that the intrapulmonary volume rises within the lungs. A negative pressure is generated in the lungs in the inspiratory process, which would encourage the entrance of air into the lungs. The lung is inflated, filled with air until the full extendibility is reached, the alveolar walls become rigid, since they do not permit further elasty and an elastic retracting force is formed and at that moment the expiration begins, where the induced retracting force will reduce its three diameters generating positive pressure [62].

Ways to use mechanical ventilators:

- To pump high oxygen concentrations into the lungs.
- To help remove carbon dioxide.
- To minimize the amount of energy a patient needs to breathe so that their body can focus on battling or healing from infection.
- To breathe for a person who likes the brain or spinal cord, does not breathe due to nervous system damage or who has very weak muscles.

- Breathing for a patient who is unconscious due to a serious infection, poison accumulation, or drug overdose.

Mechanical ventilator function: A healthcare provider will insert an endotracheal tube (ET tube) through the nose or mouth of the patient and into the windpipe when a person needs to be on a ventilator (trachea). After that, this tube is attached to the ventilator. There are some tasks performed by the endotracheal tube and ventilator. To bring oxygen into the body, the ventilator forces a combination of air and oxygen into the lungs of the patient. To prevent the air sacs in the lung from collapsing, the ventilator can also hold a constant amount of low pressure, called positive end-expiratory pressure (PEEP). The endotracheal tube allows the suction of mucous from the windpipe to be removed by doctors and nurses. If a person has a tracheal blockage, such as from a tumor, or requires a ventilator for a long period, then a tracheostomy procedure may be needed. A surgeon creates a hole in the neck and trachea of the patient during a tracheostomy, then inserts a breathing tube called a tracheostomy tube into the hole. It then attaches the tracheostomy tube to the ventilator. A tracheostomy tube can last as long as possible, but if a patient no longer requires it, it does not have to be permanent and can be removed. With a tracheostomy tube, a person can speak and eat.

How is a mechanical ventilator working?

Ventilators operate by supplying oxygen directly to the lungs, and for people who cannot exhale on their own, they can even be designed to filter carbon dioxide out. The ventilator supplies oxygen into a tube implanted into the nose or mouth of the patient in a process known as intubation or put directly through the trachea, or a surgical procedure known as tracheostomy is considered a windpipe. A mechanism (a ventilator) that pumps a combination of air and oxygen into the tubing and the lungs is attached to the opposite end of the tube. Before it enters inside the bloodstream, the air is pumped up and humidified. To help avoid the collapse of small air sacs (alveoli) in the lungs, the ventilator also plays a crucial function in maintaining positive air pressure.

Optimum artificial ventilation is accomplished when the patient's blood system is maximally oxygenated and at the same time, the detrimental effect on the cardio-pulmonary system is reduced in an artificial ventilation system and a procedure for monitoring the artificial ventilation system for achieving optimized artificial ventilation of a patient's lung system. The ventilation system is fitted with a gas distribution unit to provide a patient with controllable inspiration pulses, a monitoring unit to calculate at least one parameter relevant to the function of the lung system, such as a blood gas analyzer, and a control unit to assess the optimum peak inspiratory pressure and pressure amplitude for the inspiration pulse based on the blood gas parameter measured.

Mechanical ventilation operates with the use of a positive pressure breath and is based on the airway system's conformity to and resistance to the pressure the ventilator requires to create to provide a certain tidal volume (Vt). The amount of air inhaled into the lung. Compliance and resistance are complex and the conditions leading to intubation will influence them. Understanding the changes in conformity and intensity will allow you to select the right ventilator strategies.

Mechanical ventilation consists of four stages: The trigger phase, the motivating period, the cycling phase and the expiratory phase are in place. The trigger step is the initiation of an inhalation, induced by the patient's effort or the mechanical ventilator set parameters. The inspiratory process is characterized by air inhaled into the patient. The cycling period is the short duration when the breathing is stopped but before the breathing starts. Passive air exhalation from the patient is the expiratory process.

3.2. Basic Parameters of Mechanical Ventilator Settings

In this research, by using Simulink simulation as a teaching method for the user to learn and study the key ventilation parameters environment and also concentrate on checking ventilator efficiency monitoring in the event of a shift in pathology, we suggest a ventilator circuit model. We simplified a medical ventilator model to use with mechanical ventilator waveforms and descriptions all mechanical ventilator setting parameters.

In this research, the mechanical ventilator settings considered, assuming the patient is under full sedation, are:

The key variables to manipulation of mechanical ventilation are the volume and pressure flow. All of them are connected and are mostly measured directly by the ventilator sensors. They describe all main parts of the mechanical ventilator:

Tidal Volume Vt or TV or VT: The amount of air between the lungs and the outside world is normally shared. In most words, without any extra effort, the amount of air you inhale or exhale. A Vt should be between 6 and 8 mL per kg of body mass for a human. It can be rounded to 500 ml per inspiration, but the exact volume is accomplished with this calculator. The amount of air passing within or outside the lungs during each breathing period is the tidal volume. In an average healthy, adult male, it measures about 500 mL and in a healthy female, about 400 ml. It is a critical therapeutic parameter for adequate ventilation. Oxygen from the ambient atmosphere reaches the lungen as a human breathes in. It then diffuses to enter the arterial blood via the alveolar-capillary interface. Carbon dioxide constantly evolves at the same time as digestion happens. Expiration happens to remove and prevent carbon dioxide from building up in the body. Physiology refers to the amount of inspired and expired air that serves to stably sustain blood levels of oxygen and carbon dioxide [63].

Determines the target tidal volume by height and depth of ETT placement.

Estimating ideal ETT position: In this calculator, the proper main tract intubation, hypoxemia, and pneumothorax (when ETT is too depth full) or damage to the vocal cord or accidental extubation (when ETT is too shallow) is determined based on the optimum patient height of an endotracheal tube.

$$\text{ETT depth from front teeth (cm) (Chula formula)} = 0.1 \text{ x Height in cm} + 4 \quad (3.1)$$

While the height measurement does not rule out the need for chest x-ray, auscultation or ultrasound to assess the ETT depth, it does help to protect the ETT in the early stage.

If critical hypoxemia is present, it will automatically avoid saturation by sending ETT into the middle of the trachea. In the original study, 100 patients of equal gender with general orotracheal intubation anesthesia were tested for the formulation of Chula. The distance from the ETT end to the carina and the distance from the top border of the ETT cuff to the vocal cords was calculated by a fiber-optical bronchoscope (inserted in the ETT during intubation) [64].

ETT – Endo Tracheal Tube use

A tracheal tube is a catheter applied by doctors to facilitate the patient's adequate breathing. In the event of, for example, serious pneumonia, they inject it into the patient's mouth or nose and the trachea.

When do we use endotracheal tubing any other way?

- To make mechanical ventilation and volatile anesthetic inhale during general surgery and after major surgeries;
- to protect the airways, particularly in unconscious patients, from aspiring the stomach material to the lungs. Doctors determine whether the tube has to be inserted on the Glasgow coma scale, an empirical means of recording the consciousness of a human. Why do we stop aspiration? Ok, pneumonia is sometimes caused;
- Encouraging breathing with or without breathability in people with difficulties. Pneumonia, such as extreme COVID-19, post-stroke un-conscious patients, poisoning or serious injury, maybe more detailed. Also, when a patient needs heavy breathing sedatives, mechanical ventilation assistance is a secure pickup.

- The neonatologist will determine on the temporary application of an endotracheal conduit. premature neonates can exhibit respiratory distress;

The range of tidal volume is between 6 and 8 mL/kg body mass. You should, however, take your ideal body weight into account to be precise [64]. To find the ideal body weight (IBW) using the following equations:

$$\text{Female, IBW} = 45.5 + 2.3 * (\text{height [in]} - 60) \tag{3.2}$$

$$\text{Male, IBW} = 50 + 2.3 * (\text{height [in]} - 60) \tag{3.3}$$

or, if you prefer SI units:

$$\text{Female, IBW} = 45.5 + 0.9 * (\text{height [cm]} - 152) \tag{3.4}$$

$$\text{Male, IBW} = 50 + 0.9 * (\text{height [cm]}) - 152) \tag{3.5}$$

To find the minimum tidal volume and the maximum tidal volume applied in the below equations:

$$\text{Minimum Tidal Volume} = \text{IBW} * 6\,\frac{\text{ml}}{\text{kg}} \tag{3.6}$$

$$\text{Maximum Tidal Volume} = \text{IBW} * 8\,\frac{\text{ml}}{\text{kg}} \tag{3.7}$$

After that the input patient’s height should be change centimeter to an inch in applied in the below equation:

$$\text{cm value divides the length value by 2.54} \tag{3.8}$$

Flow Rate: The maximum flow rate, or peak inspiratory flow rate, is the maximum flow at which the ventilator produces a fixed tidal breath capacity. Flow speeds of between 60 and 120 L/min can be provided by most modern ventilators. Flow speeds should be titrated to satisfy the inspiratory needs of the patient. to finding flow rate need the tidal volume and inspiratory rate [65], to find the flow rate L/Sec should applying the below equation:

$$\text{Flow Rate}\left(\frac{\text{L}}{\text{Sec}}\right) = \frac{\text{Tidal Volume Vt}}{\text{Inspiratory Rate IS}} \tag{3.9}$$

To change the flow rate L/Sec to L/Min should applying the below equation:

$$\text{Flow Rate}\left(\frac{\text{L}}{\text{Min}}\right) = \text{Flow Rate}\left(\frac{\text{L}}{\text{Sec}}\right) * \frac{60\text{Sec}}{1\text{ Min}} \tag{3.10}$$

Positive End-Expiratory Pressure PEEP: A ventilation system in which at the end of exhalation, airway pressure is maintained above ambient pressure utilizing a mechanical impedance, usually a valve, inside the circuit. PEEP aims to raise the amount of gas left at the end of expiration in the lungs to minimize blood shunting through the lungs and enhance the exchange of gases. In ARDS (acute respiratory failure syndrome), PEEP is performed to allow a decrease in the amount of oxygen being given. Positive end-expiratory pressure (PEEP) is an alveolar pressure that arises at the end of expiration and may be of two kinds: extrinsic (used by a ventilator) or intrinsic (used by a ventilator) (caused by an incomplete exhalation). Alveolar pressure and alveolar volume are increased by applying PEEP. By reopening and stabilizing collapsing or unstable alveoli, the expanded lung volume increases the surface area. This positive pressure splinting, or propping open, of the alveoli increases the ventilation-perfusion match, reducing the shunt effect. In conjunction with mechanical ventilation, PEEP is a form of therapy used. PEEP retains the patient's airway pressure above the ambient level at the end of mechanical or voluntary exhalation by exerting pressure that opposes passive emptying of the lung. Usually, this pressure is accomplished by sustaining a positive flow of pressure at the end of exhalation. In centimeters of water, this pressure is measured [66].

Peak Inspiratory Pressure PIP: The highest level of pressure added to the lungs during inhalation is peak inspiratory pressure (PIP). In mechanical ventilation, the number represents a positive water pressure in centimeters (cmH2O). It can also be referred to as the maximum inspiratory pressure (MIPO) in normal breathing, which is a negative attribute. For every airway resistance, peak inspiratory pressure rises. Increased secretions, bronchospasm, biting down on breathing tubing, and diminished conformity with the lungs may be things that would improve PIP. Unless the patient has acute respiratory distress syndrome, PIP can never be consistently higher than 40(cmH2O) [67].

Peak Expiratory Flow Rate PEER**:** The PEF (peak expiratory flow) calculator calculates the maximum expiratory speed of a human.

This calculator can be used to compare the approximate value, depending on age, gender and height, to that obtained with a peak flow meter via the physical calculation [68].

The calculator above calculates the patient's age, gender and height as the (predicted) peak expiratory flow:

• Age – the PEFR has a special formula for the assessment of pediatric patients;

• Gender – the PEFRs are smaller for women than for men;

• Hight – high PEFEs are normal for big people. However, inches are translated into centimeters used in the formula and are input in centimeters or inches.

Each of the following equations calculates the peak expiratory flow rate:

$$\text{Male} = \Big(\big((\text{height in m} * 5.48) + 1.58\big) - (\text{age} * 0.041)\Big) * 60 \tag{3.11}$$

$$\text{Female} = \Big(\big((\text{height in m} * 3.72) + 2.24\big) - (\text{age} * 0.03)\Big) * 60 \tag{3.12}$$

The calculated one is compared to that and a percentage is derived if a measured peak flow value is available. It shows the difference between the prediction (normal for age, sex, and height) and the actual value, in the below Figure 3.2 and Figure 3.3 calculate PEER for the patient is male and female in the Simulink file.

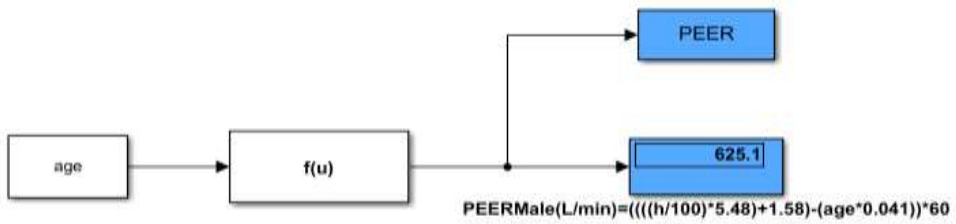


Figure 3.2. Calculate PEER for the patient is male in the Simulink file

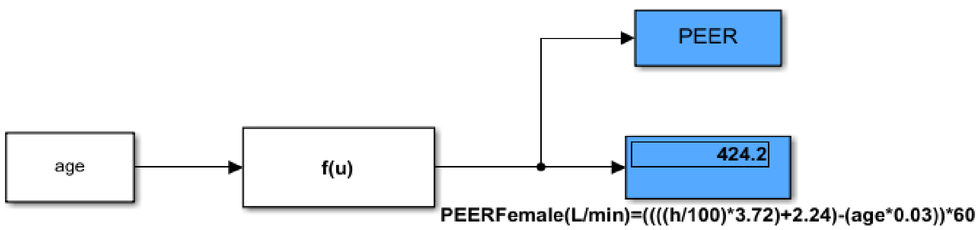


Figure 3.3. Calculate PEER for a patient is male in the Simulink file

Plateau Pressure Pplat: Plateau pressure is the pressure which is applied to the narrow airways and alveoli by the mechanical ventilator. At end-inspiration, the plateau pressure is measured for an inspiratory hold maneuver that is 0.5 to 1 second on the mechanical ventilator. During an inspiratory pause on the mechanical ventilator, it is weighed. Hold plateau pressure <30cm of water determined on a ventilator in ARDS.

As a result of decreased compliance, a rise in pressure at final inspiration. Measured by carrying out a ventilator 'inspiratory hold' Increased Platting causes include lung, pleura, chest wall, dyssynchrony patient-ventilator.

Plateau pressure is the volume-compliance relationship if no flow exists [69].

Mean Airway Pressure Paw: Describes the mean pressure exerted during mechanical ventilation at positive pressure and correlates with alveolar ventilation, hemodynamic efficiency and arterial oxygenation.

Two phase-specific measurements of PIP (IS/Ttot, where Ttot is the total lung cycle time) and PEEP (Paw is specified by PIP) [70]. To find the Paw applied in the below equation:

$$\text{Paw} = \left(\frac{(\text{Inspiratory Time} * \text{Frequency})}{60}\right) * (\text{PIP} - \text{PEEP}) + \text{PEEP} \tag{3.13}$$

The PIP is the pressure applied to the lungs during inhalation and rises with some airway resistance (due to elevated secretions, bronchospasm or diminished conformity with the lung).

PIP FE (such as in acute respiratory distress syndrome) can help to raise the tidal volume and eliminate CO_2 and decrease $PaCO_2$, but natural increases can enhance oxygenation.

Positive End-Expiratory Pressure (PEEP): Is an alveolar pressure that arises at the end of expiration and may be of two kinds: extrinsic (applied by a ventilator) or intrinsic (caused by inadequate exhalation) [71].

Arterial Oxygen Partial Pressure PaO_2: The partial oxygen pressure measured from arterial blood in Intensive Care Units (ICUs) and wards is PaO_2. Reflects the quantity of dissolved oxygen gas from the blood. The effects of the pull of oxygen into the bloodstream from the atmosphere are mainly measured here. A PaO_2 electrode is used to measure this. It is the oxygen partial pressure (tension) in the gas phase in equilibrium with blood. Blood hyperoxia or hypoxia, respectively, signify high or low levels. In venous blood, PO_2 is smaller than in arterial blood due to peripheral tissue absorption of oxygen [72].

Oxygen pressure in the blood is indicated by the PaO_2 measurement. Many stable adults have a PaO_2 of 75-100 mmHg within the standard range.

PaO_2 is determined directly by a Clark electrode which can be used by a few contacts to determine oxygen exchange.:

- Normal PaO_2 values = 75-100 mmHg

- Estimated normal PaO_2 = 100 mmHg – (0.3) age in years
- Hypoxemia is PaO_2 < 50 mmHg

If there is a PaO_2 level of less than 75 mmHg, it means that a person is not getting enough oxygen.

A low level of PaO_2 may lead to an underlying state of health, such as emphysema, chronic obstructive pulmonary disease, or COPD, pulmonary fibrosis, a problem with the heart.

PaO_2/FiO_2: The oxygen-inspired fraction is FiO_2. Your FiO_2 is equivalent to 21 percent if you breathe normal air. Oxygen-enriched oxygen is obtained from people with hypoxemia, respiratory problems, or some other medical problem impacting the creativity process. Their FiO_2 is greater than 21 percent in these cases, but usually less than 50 percent to prevent oxygen toxicity [73].

- As FiO_2 increases, PaO_2 increases. The ratio eliminates the insufficient or reduced exchange of oxygen.
- Normal PaO_2/FiO_2 is >400 mmHg.
- Approximate PaO_2 by multiplying FiO_2 by 5 (example, FiO_2 = 21%, then PaO_2 = 100 mmHg).

Oxygen Saturation SaO_2: The hemoglobin percentage that is completely mixed with oxygen is assessed.

Although this measurement can be derived from an arterial or venous blood sample, the most desirable attribute is that it can be obtained by the use of a "pulse oximeter" non-invasively and continuously.

Normally, space air oxygen concentration reaches 95 percent. This can be improved to 98-99 percent with deep or quick breathing. The oxygen saturation can be pushed to 100 percent when breathing oxygen-enriched air (40–100 percent) [74].

The saturation of oxygen would decrease if:

- The levels of inspired oxygen, such as at increased altitudes, are reduced.
- Upper or middle airway obstruction exists (such as during an acute asthmatic attack)
- There is a major alveolar pulmonary condition that interferes with the free flow of oxygen across the alveolar membrane.

The saturation of oxygen would increase if:

- Deep or quick respiration occurs
- The levels of inspired oxygen are raised, such as breathing from a 100% oxygen supply.

Oxygenation Index OI: In papers or publications are written by experts in intensive care, the medical abbreviated "OI" can be included. The Oxygenation Index is used to assess the patient's respiratory capacity.

Oxygenation in medicine is a mechanism by which a human contributes oxygen to the blood. It depends on the quantity of gas inhaled, the oxygen content in it as well as the cellular or fluid barrier in the lungs.

The physiological way of oxygenation can occur through the lungs or through the use of a state of the art system called extracorporal membrane oxygenation (ECMO). It is an artificial, short-term substitution of the lungs and heart of human beings [75].

Oxygenation Index formula:

You would need the following data to measure the oxygenation index:

- ✓ Mean Airway Pressure (M_{Paw});
- ✓ PaO_2 - Partial pressure of the oxygen in the arterial blood: and
- ✓ FiO_2 - A fraction of inspired oxygen.

$$OI = (FiO2 * \text{Mean Airway Pressure})/PaO2 \tag{3.14}$$

In the following Table 3.1 appears interpretation of results in the oxygen index.

Table 3.1. Appears interpretation of results in the oxygen index

Interpretation of results	
Oxygen Index < 5	Stable Individual
Oxygen Index between 5 - 25	Lung Disorder Suggests
Oxygen Index between 25 - 40	Greater Mortality
Oxygen Index > 40	Dream about using ECMO

Higher PaO_2 values and lower FiO_2 values are always a hopeful indication - it means the patient can sustain a high level of blood oxygen despite a poor inhalation oxygen level.

FiO_2 is the fraction of inspired oxygen found in the air in which we respire. It is highly important for intensive care patients as the doctor can artificially manipulate this parameter and so needs to be closely watched.

This FiO_2 calculator can be used for measuring the oxygenation index.

PaO_2 / FiO_2 Ratio: Another metric we can achieve with the calculator oxygenation index is the PaO2/FiO2 ratio. It warns us of the risk for ARDS (Acute Respiratory Distress Syndrome), a sudden case of lung insufficiency that could lead to the death of a patient, in the following Table 3.2 described the three phases of ARDS decide the PaO_2/FiO_2 ratio.

Table 3.2. The PaO2/FiO2 ratio is determined by three phases of ARDS

200 - 300	Slight
100 - 200	Medium
0 - 100	Strong

The Inspiratory: Expiratory Ratio (I: E Ratio): Applies to each inspiratory and expiratory step proportion of a breathing cycle. The length of each step-in combination with the total respiratory rates would depend on this ratio. Divide 60 seconds by respiratory rate for the cumulative duration of the air cycle. Inspirational duration and expiratory time are measured based on the set ratio by portioning the air cycle. For example, a patient with a 10-minutes respiratory rate has a 6-second breath duration. A standard I: E ratio will be 1:2, if this ratio is extended to the above patient, the 6-second breath duration would break down to two seconds and four seconds. Increasing the I: E ratio to 1:3 would result in 1.5 and 4.5 seconds of motivation. Thus, a higher I: E ratio in the same length of breath results in less inspiratory and longer expiratory periods [71]. To find the I:E ratio applied in the below equation:

$$\text{I: E Ratio(total cycle in one breath)} = \frac{\text{1 minute(60 Seconds)}}{\text{Respiratory Rate}} \tag{3.15}$$

usually, inhalation =1 second

$$\text{I: E Ratio} = \text{Inspiratory Time} - \text{Expiratory Time} \tag{3.16}$$

Minute Ventilation Mv: The average amount of gas intake or exhaust per lung per minute is minute ventilation (Mv). The tidal volume is equivalent to the respiratory rate. This volume is equal. The normal person is at rest ~450 ml/breath x 10 breath/min = 4500 ml/min. The normal person is at rest. Mv =Vt x RR.

Minute volume can be determined by combining the two values if both tidal volume (Vt) and respiratory rate (RR) are known. The effects of dead space on alveolar ventilation, as seen in the "Relationship to other physiological rates," must also be taken into account [76].

The total volume of gas entering or leaving the lung per minute is known as minute ventilation and is measured as the product of tidal volume and respiratory rate.

The minute ventilation equation that is most widely used is:

$$\text{Minute Ventilation}\ \left(\frac{\text{ml}}{\text{Min}}\right) = \text{Tidal Volume in ml} * \text{Respiratory Rate in res/min} \tag{3.17}$$

In the following Table 3.3 described the standard adult range.

Table 3.3. Described the standard adult range for tidal volume, respiratory rate, minute ventilation

Variables	Lower limit	Higher limit
Respiratory Rate (RR)	10 resp/min	16 resp/min
Minute Ventilation (Mv)	4000 mL/min	8000 mL/min
Tidal volume (Vt)	400 mL	600 mL

However, owing to physiological dead space, not all the minute breathing volume takes part in the gas exchange. The volume used in the exchange of gases is the difference between the two, the breathing of the alveolar minute. From the 450 mL that enters the airways about 300 mL reaches the pulmonary area. The majority of the 150 mL remains in dead space and participates actively in the exchange of alveolar gas [76]

.

4. MATERIAL AND METHOD

4.1. Requirements of the Recommended Method

In this research, we use the mathematical model to create the intelligent healthcare system such as mechanical ventilator the using the mathematical models: Let us start with a general meaning to grasp mathematical models. In our literature, there are several different descriptions of mathematical models. The differences between these definitions can usually be explained by the different scientific interests of their authors. For starters, it is obvious that the concept of a math's model is a series of equations to determine the evolution in the time-space of the physical system. Many economic or sociological problems, for example, cannot be solved based on time or equations alone. Thus, a more general definition of mathematical models is needed if one wants to cover all kinds of mathematical models used in science and engineering. Let us start with the following attempt of a definition: A mathematical model is a set of mathematical statements M = {1, 2, ..., n}

This description encompasses all sorts of science and engineering mathematical models as needed. But the description has a problem. A basic mathematical argument like f(x) = ex, for example, will be in the context of this description a mathematical model.

The Basic and quantitative approach to understanding and evaluating dynamic processes and phenomena.

Supplement and often combine theory and experiments. Digital physics, chemistry, mechanics, materials, computer scientist, genetics. Wide-ranging appreciation of modeling. Simulation methods hands-on insight. Establish expertise of contact with clinicians.

Mathematical modeling is the practice of transforming problem from implementation into traceable mathematical formulas that provide insights, answers and advice useful for the original application in theoretical and numerical analysis. in many implementations is indispensable. achieved in many additional applications. provides precise and problem-solving guidance. makes a comprehensive machine interpretation. Pave the way for enhanced machine architecture or control. Facilitates the effective use of digital computers. Teaching mathematical modeling is an important transition from theoretical mathematics to application-focused math's and lets the student master the complexities of our new technical society. It is also an important step.

Identify Real-World Problem:

- Perform context analysis, concentrate on a workable problem.
- Participate in the operation of inquiries (Labs), if possible.
- Train with the following programming tools: MATLAB, Mathematica, Excel, Java.

4.2. Components Required for the Implementation of the Recommended Method

In this research creating the digital twin for mechanical ventilators for monitoring test, the digital twin is defined as the virtual model of the actual behavior of service and the results it generates in a physical product. In the simplest term for the digital twin, the digital twin is a more imaginary example of the operation, product or service. the digital copy of a physical object is called a digital twin. It includes the model of the physical object, the object's data, one-to-one comparisons with the object, and the ability to track the object. Digital twin technology, as an integrated data, model and analysis tool on complex products, enables manufacturers to better understand their products in product design, real-time simulation, tracking and optimization, and to analyze them accordingly. Testing on a digital twin built with data from complex products that are costly and difficult to test in real life allows us to try the product the easy way before we present it to the physical world. The digital twin also decreases running costs and increases equipment and property life. Digital twins add value to traditional working approaches by improving awareness, optimization in the area of use, and work on changeable conditions for preventive care. It can reduce operating expenses and potential capital expenses by extending the life of the object they represent and optimizing its operating performance, combine the mathematical model with Simulink-MATLAB to create the Simulink file use many kits for applying all mathematical equation about the main parameters of the mechanical ventilator and appears all output in the application with numbers and graphs, in the following Figure 4.1 describe the steps in mechanical ventilator application.

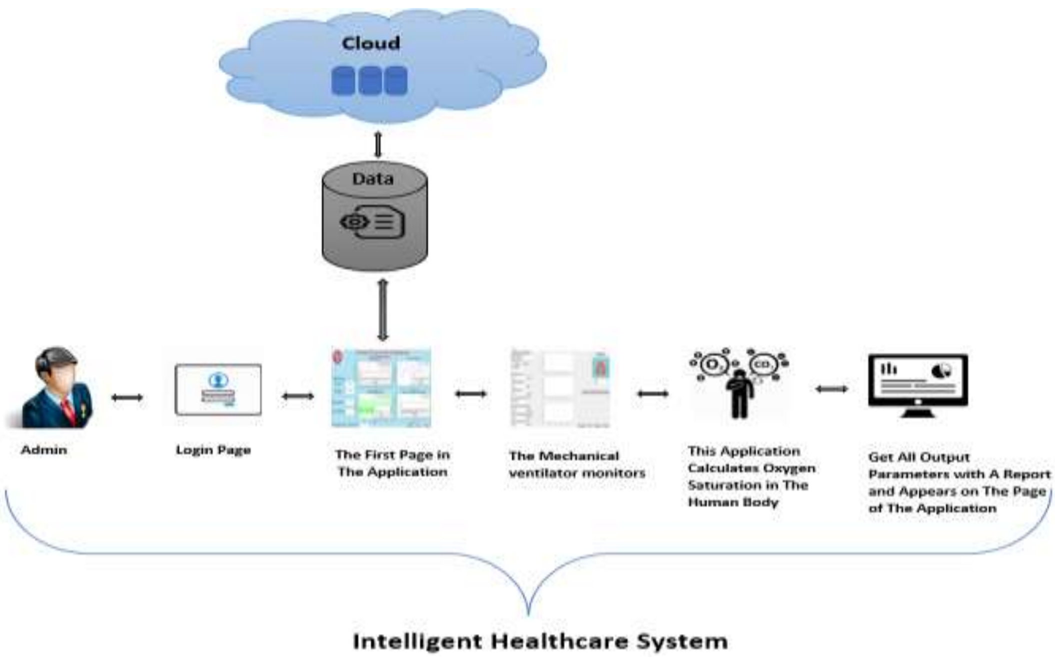


Figure 4.1. Describe the steps in mechanical ventilator application

Digitalization and novel technology, such as digital twins and artificial intelligence, allow the speed, performance, consistency and versatility of industrial businesses to evolve in an unparalleled way. A digital twin is a digital representation that digitally simulates an entity, mechanism or system in real life. Simulation After modeling a real theoretical or physical system in a computer environment, performing experiments to understand the behavior of the system or to evaluate various strategies to operate the system using this model is a technique that evaluates the properties and behavior of these through computers. The technical meaning most used to simulate words today is to create an artificial environment or mimic a system in time for the operation of any process or system.

They have many benefits using simulation it forces system analysts to think more broadly and broadly. It can allow examining the internal interactions of any system and to make experiments on them. It forces the dynamical structures to be examined by revealing the evolutionary nature of systems. We can examine the behavior of the system under changing conditions and new situations. The real times of dynamic systems can be examined in a narrowed or extended period. The data required for simulation can often be obtained very easily. After finding analytical solutions with mathematical models, simulation can be used to verify the accuracy of analytical solutions. Simulation methods can close this gap when the system's data is insufficient or not available. After the simulation model is set up, it can be used for the desired time to examine different states of the system.

Generally, cloud-based systems are used to describe programs that work by online knowledge sharing in the context of data collection and deployment of information devices. More literally, it is the transfer in programs functions, such as data processing and storage, from local computers to devices that do this job professionally, such as the internet.

Cloud technology is a form of online infrastructure that offers resource sharing between internet-based cloud computing network users of data processing resources such as a server, storage, database, network, applications, analysis, and machine intelligence.

Cloud provides data storage on external devices from any computer on the internet. Instead of storing the files on their disks, clients send them to a data server operated by the cloud provider.

Cloud often includes users who link to a distributed data system over a network, so it includes pooled computational space, applications and other services. This helps users to keep their applications and apps continuously updated while still allowing them to use the computing capacity of a large network. Social networks such as Facebook, webmail clients such as Gmail, online banking applications, are well-known, regular cloud-based services.

Both consumers and technology businesses, cloud computing has multiple opportunities, cost savings speed, global flexibility, productivity, performance, reliability, security, data recovery, privacy, arrangement, access.

5. RESULT AND DISCUSSION

In this research, surveillance monitoring of an artificial mechanical ventilator was added. Using MATLAB's Simulink toolbox, every model was planned and implemented. This model is ideally favorable for an artificial ventilation analysis of simple ventilation parameters.

5.1. Technologies Used for Application

MATLAB engineering and Simulink: Millions of developers and researchers use MATLAB to analyze the data and build the structure that shapes the environment around us in the center of MATLAB is a highly professional programming language which helps scientists to directly express the matrix and array of mathematics. MATLAB offers a quick toolbox library covering all facets of signal and image processing, control systems wireless communication and computational finance to robotics deep learning and artificial intelligence and more. The MATLAB is built for the ways you believe, particularly for engineers and scientists. Simple to understand and use, it allows you to directly communicate your thoughts and places the tools you need. Explore ideas quickly see results and visualizations right next to the code that produces them and the only MATLAB include pre-built apps and helps you clearly to construct your own for the best way to evaluate and build if point and click are. Extend the work on clouds and enterprises platforms to Simulink with thousands of packages and toolboxes shared by GitHub and elsewhere or automatically build code that millions of engineers and scientists use MATLAB to share their future through testing around the world to create smart new systems.

MATLAB is a number kit that is ideally suited for the resolution of linear systems, differential equations and problem engineering. An expert in MATLAB kit with the visual user interface for mod eling and learning engineering control systems, Simulink is the basic options list in the following Figure 5.1, which will be accessible when calling Simulink from MATLAB.

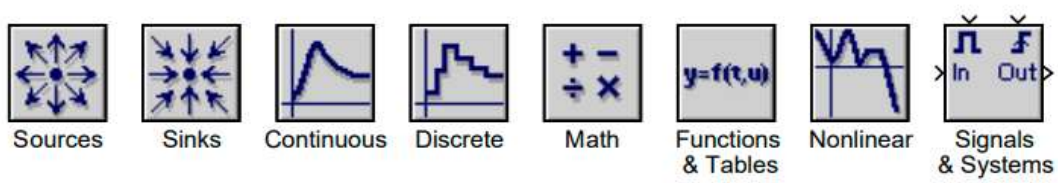


Figure 5.1. Simulink is the basic options list

The model is extended to the query or problem. A plan for solving the problem or answering the query.

Simulink is an extension to MATLAB which enables engineers to construct dynamic physical systems computer models quickly and accurately with a notation of block graphs. linear and non-linear structures – continuous-time and discrete-time elements-schematic animations are available due to the development and conversion of the diagram block to the programming languages, a diagram block of the mathematical dynamic system model has been developed. The programming software in Simulink is the block diagram which reduces the possibility of computer programs failing to execute the block diagram correctly.

Simulink uses the model of the mathematical form in the block diagram and assumes that the physical model will have a complex reaction to solve the equations.

5.2. Simulation Results

Mechanical Ventilation: The procedure used to transfer gas from to and from, the lung via an exterior system that is connected directly with the patient can be described as mechanical ventilation. Mechanical ventilation may have a wide variety of therapeutic objectives: sustaining a gas exchange, reducing or eliminating respiratory attempts, reducing systemic and myocardial O_2 intake, achieving lung extension, sedations, anaesthesia and muscle relaxation, and stabling thoracic walls, etc. Negative extrathoracic pressure or occasional positive pressure can be used to ventilate. Positive-pressure ventilators are classified by cycling system as pressurized, flow-cycled and mixed, and as irregular or steady fundamental flows based on the form of flow in the continuous flow vans. Finally, high-frequency fans are known as intermittent positive pressure, high frequency oscillatory and high-frequency jet ventilators by their high-frequency mechanism.

Air passage in and out of the lungs is important to breathing. The diaphragm and chest muscles generally do this. The capacity of these muscles to do this function may be affected by several medical conditions including:

- Dystrophy of the muscles
- The disease of motor neurons, namely ALS
- Brain respiratory damage
- polio
- Gravitational myasthenia
- Breathing muscles affecting myopathy
- Scoliosis

Mechanical ventilation, particularly in night sleep apnea, can also be used when the airway is obstructed. Mechanical ventilation may be required within restricted hours of the day or 24 hours depending on the state of the patient only at night. Any patients only need a brief period of mechanical ventilation during recovery from traumatic nerve lesions, for example. Others need to do so chronically and may devote more hours on the progression of their illness.

The use of an oxygen tank would not mean automatic breathing. In patients whose gas exchange potential has reduced due to either lung injury or obstruction of the main airway, supplemental oxygen is used. The muscles that carry air to these patients perform well, but very little oxygen can be shared in the remaining lungs, thereby providing each breath with a higher concentration. Most patients with artificial ventilation do not require extra oxygen in the same way. Their potential for exchange of gas is natural, but they cannot transfer air properly into and out of the lungs. Excess oxygen can potentially be harmful since its reaction to excess carbon dioxide in the lung is usually enhanced.

Mechanical ventilation systems of various types are available. Nearly any device uses a fan, a mechanism that moves air through a conduit to bring to the airways of the patient. The air may be supplied with a nasal or facial mask, or with a trachea (tracheostomy) opening. Most seldom, when there are low pressure and oxygen in the lungs, and when it rises, air flows out, the pressure around the patient's chest varies rhythmically.

Mechanical breathing is life-saving and gives patients warmth and trust. Proper breathing restores blood amounts of oxygen and carbon dioxide, enhances night sleep and increases physical function. It can extend life considerably in combination with good respiratory hygiene. Patients suffering from advanced diseases such as ALS may choose to decide on end-of-life before mechanical ventilation starts or before contact has been lost, in the following Table 5.1 shows all parameters and symbols and units.

Table 5.1. Physiological Parameters

Parameters	**Symbol**	**Units**
ETT	Endotracheal Tube use	cm
C	Compliance	L/cmH_2O
IS	Inspiratory Rate	Second
Flow	Flow Rate	L/Second
h	Height	cm
MvMax	Maximum Minute Ventilation	ml/min
MvMin	Minimum Minute Ventilation	ml/min
IBW	Ideal Body Weight	Kg
RR or F	Respiratory Rate or Respiratory Frequency	BPM
VtMax	Maximum Tidal Volume	ml/kg
VtMin	Minimum Tidal Volume	ml/kg
PIP	Peak Inspiratory Pressure	cmH_2O
Pplt	Plateau Pressure	cmH_2O
Raw	Airway Resistance	cmH_2O
PEEP	Positive End Expiratory Pressure	cmH_2O
TCT	Total Cycle in One Breath	Second
Paw	Mean Airway Pressure	cmH_2O
P/F Ratio	PaO2/FiO2 Ratio	mmHg
OI	Oxygenation Index	%
PaO2	Arterial oxygen partial pressure	mmHg
FiO2	The fraction of Inspired Oxygen	%
PEER	Peak Expiratory Flow Rate	L/min
SaO2	Saturation of Percentage Oxygen	%
	Airway Resistance Pressure	cm
	Pressure Gradient	cmH_2O
	Peak Pressure	cmH_2O

In this work, the usage of MATLAB is a programming platform designed mainly for engineers and scientists. The coronary heart of MATLAB is the MATLAB language, a matrix-primarily based language permitting the maximum herbal expression of computational mathematics.

You may use MATLAB:

- Data review
- Algorithms are built
- Designing apps and templates

The language, software, and integrated math features permit you to fast discover more than one processes to reach a solution. MATLAB helps you to take your thoughts from studies to manufacturing with the aid of using deploying to agency programs and embedded devices, in addition to integrating with Simulink and model-based design.

Build software with MATLAB user graphical interfaces: Graphical Consumer Interfaces (GUIs), additionally called apps, offer point-and-click on manipulating of your software program applications, eliminating the need for others to learn a language or type commands to run the application. You can percentage apps each to be used inside MATLAB and additionally as a standalone laptop or net apps. The three options for creating an app in MATLAB are as follows:

• Transform scripts to a simple application: Use this method to allow them to edit variables using interactive controls if you wish to share the script with students or colleagues.

• Interactively build the app: Choose this option while designing a more advanced program that generates a user interface using drag and drops environment.

• Programmatically build an app: Choose this option anytime you choose to create a user interface for an application by writing the code yourself.

In this part the create a respiratory device monitor, the using GUI in MATLAB Program, Firstly, we made the login page in the application, we do log into the application when you write that username and password, you enter home pages from the login page.

This application has five main pages displaying all main pages from the mechanical ventilator application:

A. Login Page

In the following Figure 5.2 appear the login page of mechanical ventilator application.

Figure 5.2. The login page for a mechanical ventilator

A username is a name that describes someone on a computer system in a specific way. For instance, it is possible to set up a machine with several accounts with separate usernames for each account.

A password is a string of characters which is used on a computer device to authenticate a person. For starters, on your computer, you might have an account that allows you to log in. You must have a correct username and password to enter your account successfully. This blend is often referred to as a login. Although usernames are usually public knowledge, each user's passwords are private.

Nearly all a username with a password is combined. This combination of username/password is considered a login and is commonly used to log in to applications as shown in Figure 5.3. The verb "Login" refers to the way a secure operating device or applications is accessed. You have "Password" information that authenticates you as a user when you log in to a device. Username and password are usually provided in this detail.

The entered username is “Admin” and the password is “1234”, after that click, the login button, open the home page.

If the entered username is wrong to show the message box “Wrong Username”.

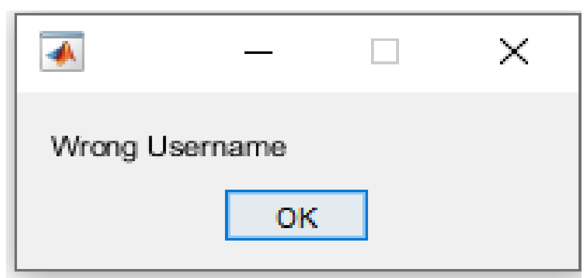


Figure 5.3. The error message box if the enter the username is wrong

And, If the entered password is wrong to show the message box “Wrong Password” as shown in Figure 5.4.

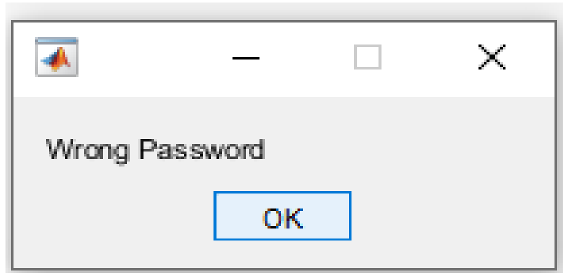


Figure 5.4. The error message box if the enter the password is wrong

If the enter username and password are wrong to show the message box error dialog “Invalid ID or Password” as shown in Figure 5.5.

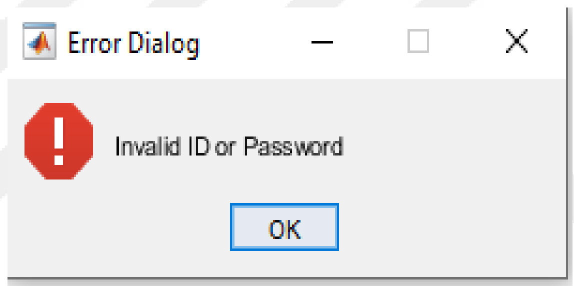


Figure 5.5. The error dialog message box if the enter the username and password are wrong

B. Home Page

In the following Figure 5.6 appear the first form in mechanical ventilator application.

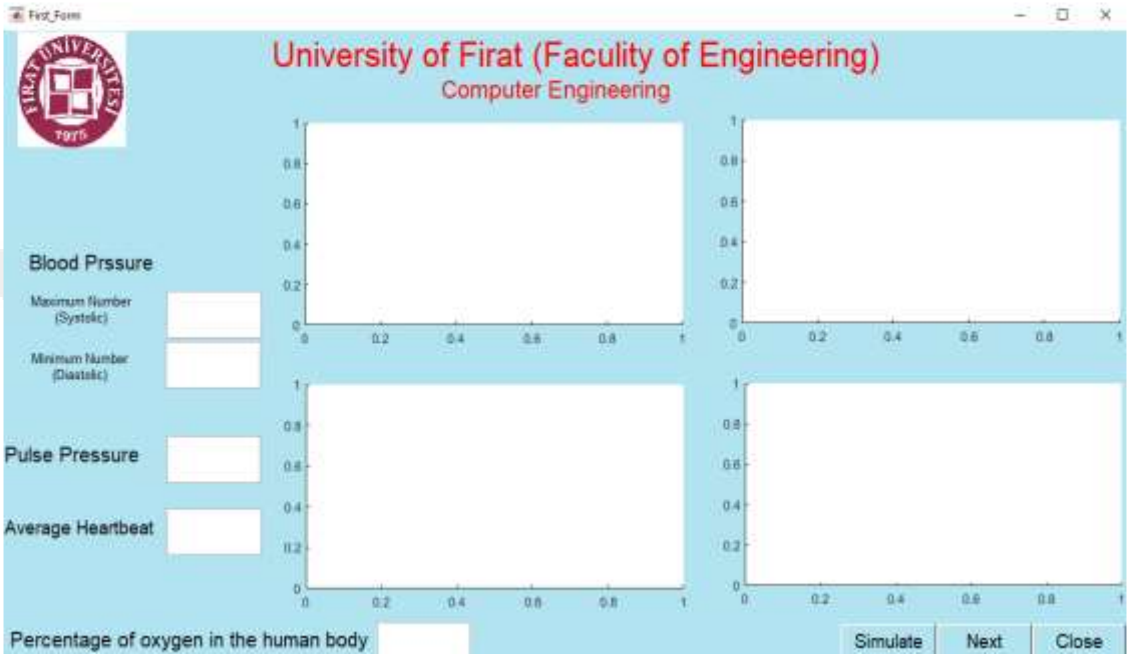


Figure 5.6. First form in mechanical ventilation

After that entered username is “Admin” and the password is “1234”, after that click, the login button, open the home page.

The home page has four part: Blood Pressure, Pulse Pressure, Average Heartbeat, percentage of O_2 in the human body. The first click the simulate button select the patient file.

The patient's file saved in the google drive using cloud and then click the “Simulate” button should be select the patient file after that applying all operations in this part.

In this home page, we have three buttons the “Close” button closes the page, click the “Next” button go to the next page, then click the “Simulate” button plot all dataset.

- Blood Pressure

The first, made dataset for blood pressure (Systolic mm Hg (Upper Number) and Diastolic mm Hg (Lower Number)) Using 30 samples (each one sample in one hour). It has five cases in the blood pressure describe in the following Table 5.2.

Table 5.2. Blood pressure categories

Blood Pressure Categories	Systolic mm Hg (Upper Number)		Diastolic mm Hg (Lower Number)
Normal	Less than 120 mmHg	and	Less than 80 mmHg
Elevated	Between120-129 mmHg	and	Less than 80 mmHg
Stage 1 High Blood Pressure (Hypertension)	Between 130-139 mmHg	or	Between 80-89 mmHg
Stage 2 High Blood Pressure (Hypertension)	At least 140 mmHg	or	At least 90 mmHg
Hypertensive Crisis (Consult your doctor immediately)	Over 180 mmHg	and/or	Over 120 mmHg

The MATLAB code for calculates blood pressure the click the simulate button loaded dataset (Patient's File) in the google drive and after than graph the dataset and the calculated average (Systolic mm Hg (Upper Number) and Diastolic mm Hg (Lower Number)) and it warns as a message in this program which type of blood pressure the patient has.

- Pulse Pressure

Pulse pressure was calculated by subtracting patient diastolic blood pressure measurement from a patient systolic blood pressure measurement.

$$\text{Pulse Pressure} = \text{Systolic Number} - \text{Diastolic Number} \quad (5.1)$$

Describe the three cases in the pulse pressure categories in the following Table 5.3.

Table 5.3. Pulse pressure categories

Pulse Pressure Categories	The Ranges
Normal	Between 40-60
Low	Between 0-40
High	Between 60-150

- Heart rate

The received dataset from heartbeat (ECG signal) for the patient and used in the MATLAB Program every 1 second take 100 the heartbeat data 1 minute=60 second,60*100=6000 Samples in 1 minute for ECG Signal. The calculated average heart rate in 1 minute then graph the ECG signal, it warns as a message in this program which type of heartbeat the patient has.

Describe the three cases in the heart rate categories in the following Table 5.4.

Table 5.4. Heart rate categories

Heart rate Categories	**The Ranges**
Normal	Between 60-100
Low	Between 0-60
High	Between 100-200

- Percentage of O_2 in the human body

We are made a dataset for O_2 in the human body graph the data and show the message patient how percentage O_2 need and average the percentage of O_2 in the human body in has 30 samples each one sample in one hour.

Describe the three cases in the oxygen saturation in the following Table 5.5.

Table 5.5. Oxygen saturation categories

Oxygen Saturation Categories	**Oxygen Saturation Level**
Normal Oxygen Saturation	The patient does not need oxygen the range from 90 to 100
Low Oxygen Saturation (Hypoxemia)	The patient needs some oxygen supplements the range from 85 to 90
Very Low Oxygen Saturation (Cyanosis)	The patient needs a lot of oxygen supplements the range from 0 to 85

In the following Figure 5.7. The first page of mechanical ventilator application displays all plot the dataset when the Simulate button is clicked.

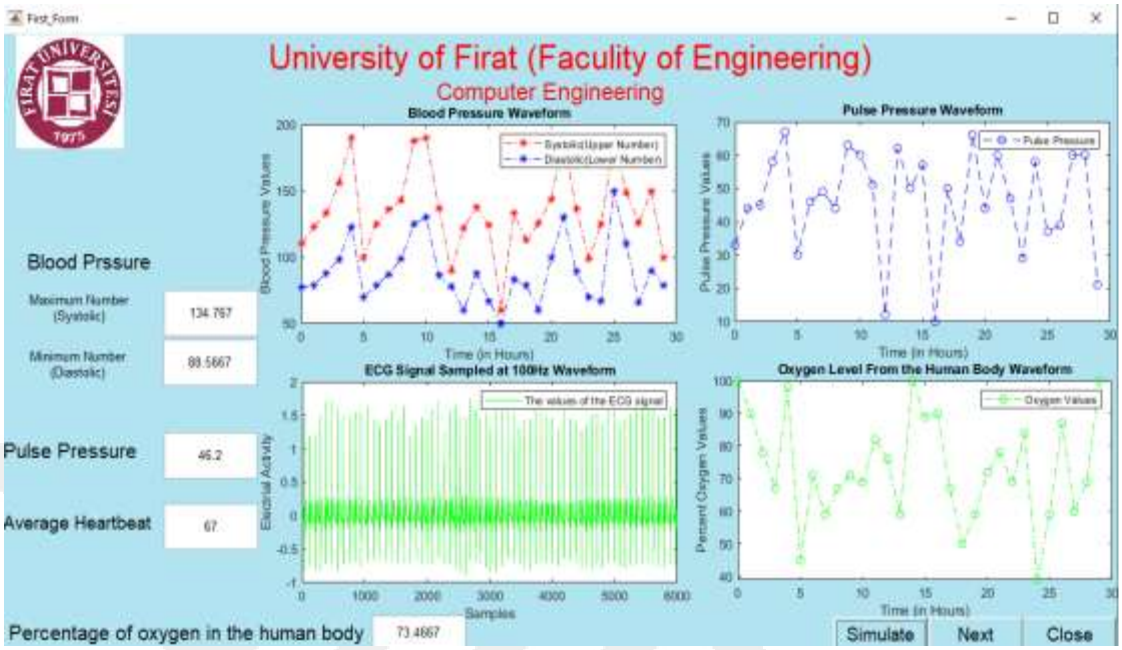


Figure 5.7. The first page of mechanical ventilator application

In the following Figure 5.8, it warns as a message in the application which type of blood pressure level, pulse pressure level, heartbeat level and percentage of O_2 in the human body the patient has.

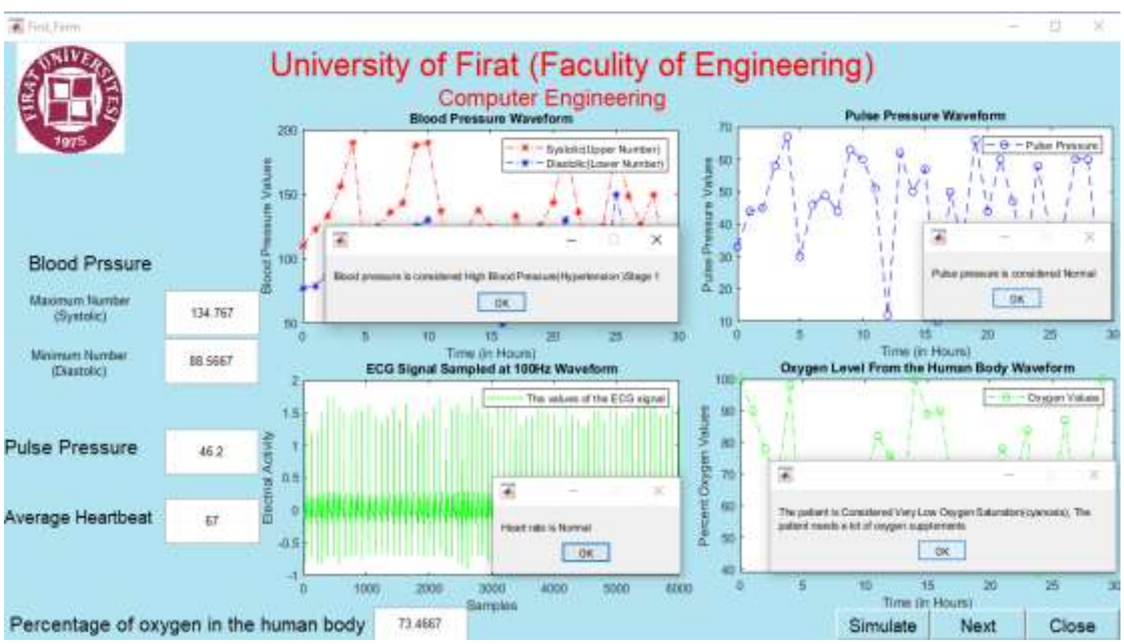


Figure 5.8. The first page of mechanical ventilator application with the message boxes

Blood pressure: Is known as blood pressure inside the arteries, the blood is pumped into the lungs as the paired muscle contracts, the pressure currently assessed is systolic. When the heart muscle relaxes, the blood stops in the vein; meanwhile, the pressure measured is the diastolic pressure. In blood pressure measurement, systolic (large) and diastolic (small) blood pressures are checked, in the following Figure 5.9 appears the two main parts in the blood pressure.

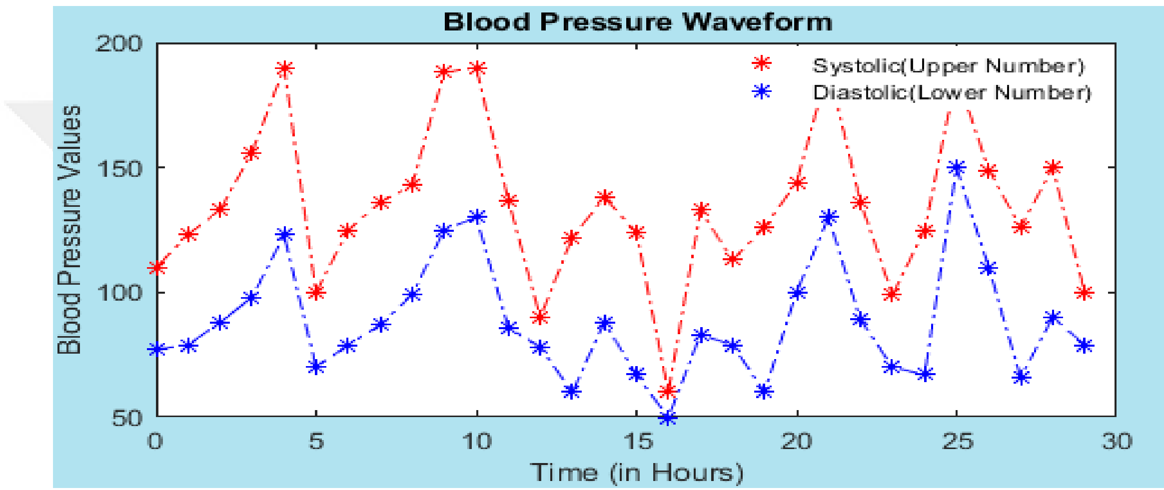


Figure 5.9. Blood pressure waveform

In this Figure 5.9 gets 30 samples, each sample in one hour, and average the systolic (upper number) and diastolic (lower number) blood and the depends on the average result shows which group the blood pressure type belongs to in this application with a message box.

In this Figure 5.9, the maximum number (systolic) is 134.767 and minimum number (diastolic) is 88.5667

Means the patient blood pressure is considered high blood pressure (hypertension) stage 1.

Pulse Pressure: The discrepancy between your systolic blood pressure, which is the top number of the reading of your blood pressure, and diastolic blood pressure, which is the bottom number, is pulse pressure. The pulse pressure may be used as a measure for the efficiency of the heart, in the following Figure 5.10 the pulse pressure waveform.

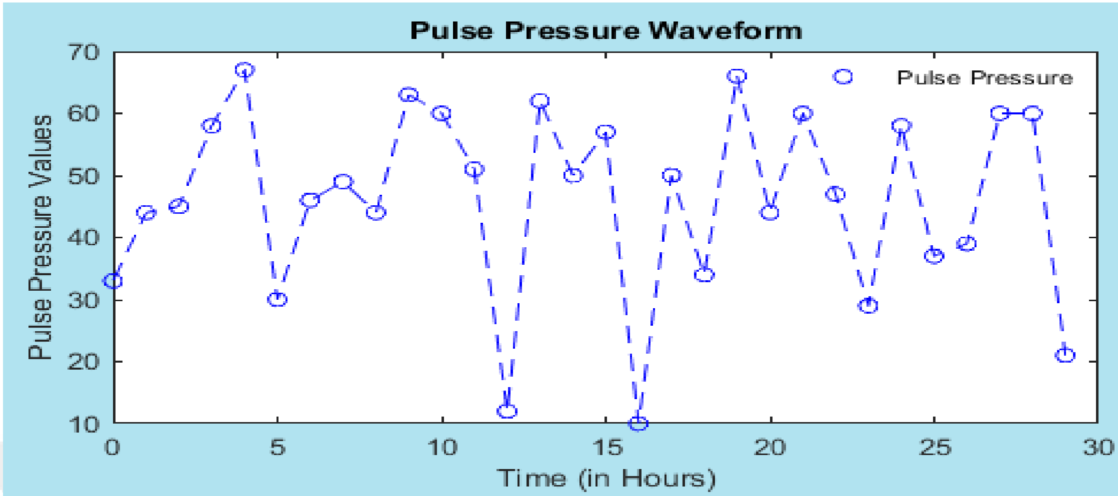


Figure 5.10. Pulse pressure waveform

In this Figure 5.10 gets 30 samples, each sample in one hour, and the difference between the systolic (upper number) and diastolic (lower number) blood and the depends on the result shows which group the pulse pressure type belongs to in this application with a message box.

In this Figure 5.10, the pulse pressure is 46.2, Means the patient pulse pressure is considered normal.

Heart rate: In medicine, in a given time, usually a minute, the number of times the heartbeats, in the following Figure 5.11 the ECG Signal Sampled at 100Hz waveform

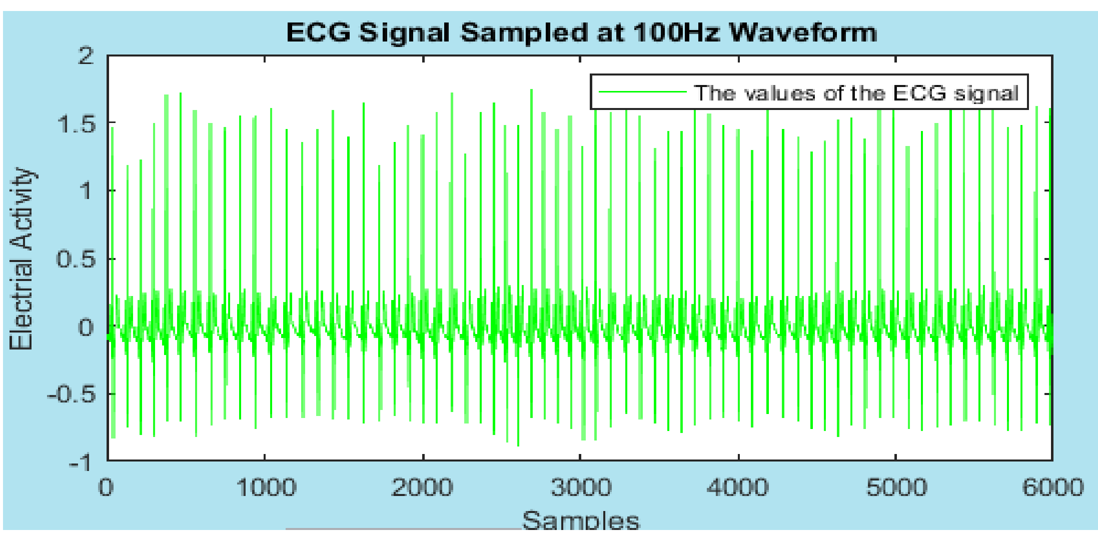


Figure 5.11. ECG Signal Sampled at 100Hz waveform

In this Figure 5.11 gets 6000 samples, calculate the heartbeat for each minute, depends on the result shows which group the heart rate type belongs to in this application with a message box. In this Figure 5.11, the average heartbeat is 67, Means the patient heart rate is considered normal.

Oxygen level in the human body: Your level of blood oxygen is an indication of how much oxygen is transferred to your red blood cells. Your body monitors the amount of oxygen in your blood. Your wellbeing needs to preserve the exact equilibrium of oxygen saturated blood, in the following Figure 5.12 appears the percentage of oxygen in the human body.

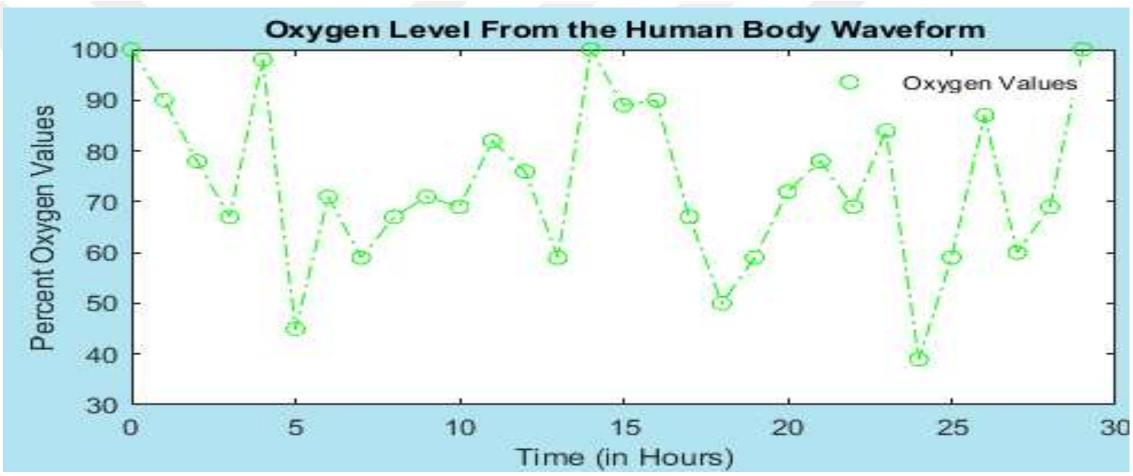


Figure 5.12. Oxygen level from the human body waveform

In this Figure 5.12 gets 30 samples, each sample in one hour, calculate the average depends on the result shows which group the pulse pressure type belongs to in this application with a message box.

In this Figure 5.12, the average oxygen level in the human body is 73.4667, Means the patient oxygen level in the human body is considered Very low oxygen saturation((cyanosis), The patient needs a lot of oxygen supplements. Means in this case it is necessary to wear a respirator to the patient.

C. Mechanical Ventilation Monitor in GUI-MATLAB

In the following Figure 5.13 appear the mechanical ventilator monitor in GUI MATLAB application.

Figure 5.13. Mechanical Ventilation Monitor in GUI MATLAB

This page of applications like a monitor of a mechanical ventilator, the application has five buttons “Please click to here to show all output” button click the button show all outputs after that calculate the Simulink file, then click “Calculate” buttons calculating all equations in the Simulink file, the “Plot” button clicks the button show all plot for tidal volume, flow rate, pressure. The “Previous” button then clicks the button go to the previous page; the “Close” button then clicks close all pages.

If Patient’s Gender is Male

In the following

Table **5.6** like a page of mechanical ventilator monitor displaying all the input and output parameters.

Click the “Calculate” button open the Simulink file special for patient's gender is equal male and calculating all operations in the Simulink file after that show all output on another page when clicking the “Please click to here to show all output” opening another page shows all output.

And save all variables in the file =

```
save('variblesForMale','S','Flow','ETT','IBWMale','C','VtMaxMale','VtMinMale','MvMaxMale','MvMinMale','Raw','TCT','Paw','PFRatio','OI','PeakPressure','AirwayResistancePressure','PressureGradient','PlateauPressure', 'PEER')
```

Table 5.6. Monitor displaying all the input and output parameters if a patient's gender is male

Input Parameters			Normal Ranges	Output Parameters		Normal Ranges
Test No.				1		
Blood Pressure	Systolic (Upper No.)	134.76	Systolic less than120 and Diastolic less than 80	SaO2	94.8743	From 90 to 100
	Diastolic (Lower No.)	88.56		Maximum Mv	9000	From 0 to 8000
Pulse Pressure		46.2	From 40 to 60	Minimum Mv	6750	From 0 to 4000
Heartbeat		67	From 60 to 100	Flow Rate	0.6 L/Sec * 60 Sec/1 min=36	From 60 to 120
Percentage of O_2 in the human body		73.46	From 90 to 100	ETT	22	Depending on the patient
Height		180	Depending on the patient	IBW	75	Depending on the patient
Gender		male	Depending on the patient	TCT	4	From 0 to 5
Age		25	Depending on the patient	OI	2.45	From 0 to 5
Ppalt		15	From 0 to 30	Maximum Vt	600	Male - From 0 to 780 Female - From 0 to 500
RR		15	From 12 to 16	Minimum Vt	450	Male - From 0 to 570 Female - From 0 to 550
IS		1	From 0 to 1	P/F Ratio	357.1429	Greater than 400
FiO2		21	From 21% to 100%	PEER	625.14	From 400 to 700
PaO2		75	From 75 to 100	Pressure Gradient	10	From 2 to 14
PEEP		5	From 3 to 5	Peak Pressure	20	From 18 to 25
PIP		20	From 0 to 30	Paw	8.75	From 10 to 15
				Raw	8.33	From 0 to 2.8
				Pplat	10	From 0 to 35

Compliance	60	From 0 to 200 cm
Airway Resistance Pressure	5	From 2 to 3 cm

If Patient's Gender is Female

In the following Table 5.7 like a page of mechanical ventilator monitor displaying all the input and output parameters.

Click the "Calculate" button open the Simulink file special for patient's gender is equal male and calculating all operations in the Simulink file after that show all output on another page when clicking the "Please click to here to show all output" opening another page shows all output.

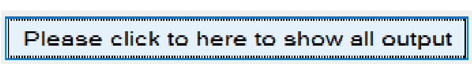
And save all variables in the file

```
save('variblesForFemale','SFemale','FlowFemale','ETTFemale','IBWFemale','CFemale','VtMaxFemale','VtMinFemale','MvMaxFemale','MvMinFemale','RawFemale','CFemale','TCTFemale','PawFemale','PFRatioFemale','OIFemale','PeakPressure','AirwayResistancePressure','PressureGradient', 'PlateauPressure','PEER')
```

Table 5.7. Monitor displaying all the input and output parameters if a patient's gender is female

Input Parameters			**Normal Ranges**	**Output Parameters**		**Normal Ranges**
Test No.				**2**		
Blood Pressure	Systolic (Upper No.)	135.667	Systolic less than120 and Diastolic less than 80	SaO2	95.7252	From 90 to 100
	Diastolic (Lower No.)	88.3333		Maximum Mv	5824	From 0 to 8000
Pulse Pressure		47.3333	From 40 to 60	Minimum Mv	4368	From 0 to 5000
Heartbeat		67	From 60 to 100	Flow Rate	0.416 L/Sec * 60 Sec/1 min=24.96	From 60 to 120
Percentage of O_2 in the human body		75.3	From 90 to 100	ETT	20	Depending on the patient
Height		160	Depending on the patient	IBW	52	Depending on the patient
Gender		Female	Depending on the patient	TCT	4.2857	From 0 to 5

Age	24	Depending on the patient	OI	3.3625	From 0 to 5
Ppalt	15	From 0 to 30	Maximum Vt	416	Male From 0 to 780 Female From 0 to 500
RR	14	From 12 to 16	Minimum Vt	312	Male From 0 to 570 Female From 0 to 550
IS	1	From 0 to 1	P/F Ratio	266.6667	Greater than 400
FiO2	30	From 21% to 100%	PEER	448.32	From 400 to 700
PaO2	80	From 75 to 100	Pressure Gradient	10	From 2 to 14
PEEP	5	From 3 to 5	Peak Pressure	22	From 18 to 25
PIP	22	From 0 to 30	Paw	8.9667	From 10 to 15
			Raw	16.8269	From 0 to 2.8
			Pplat	10	From 0 to 35
			Compliance	41.6	From 0 to 200
			Airway Resistance Pressure	7	From 2 to 3

D. If Patient's gender is equal male, the page special for showing all output if click the button 

. And showing the below Figure 5.14 in this page has two buttons: The "Undo" button clicks the button to the previous page, and "Close" button then click the button close the page.

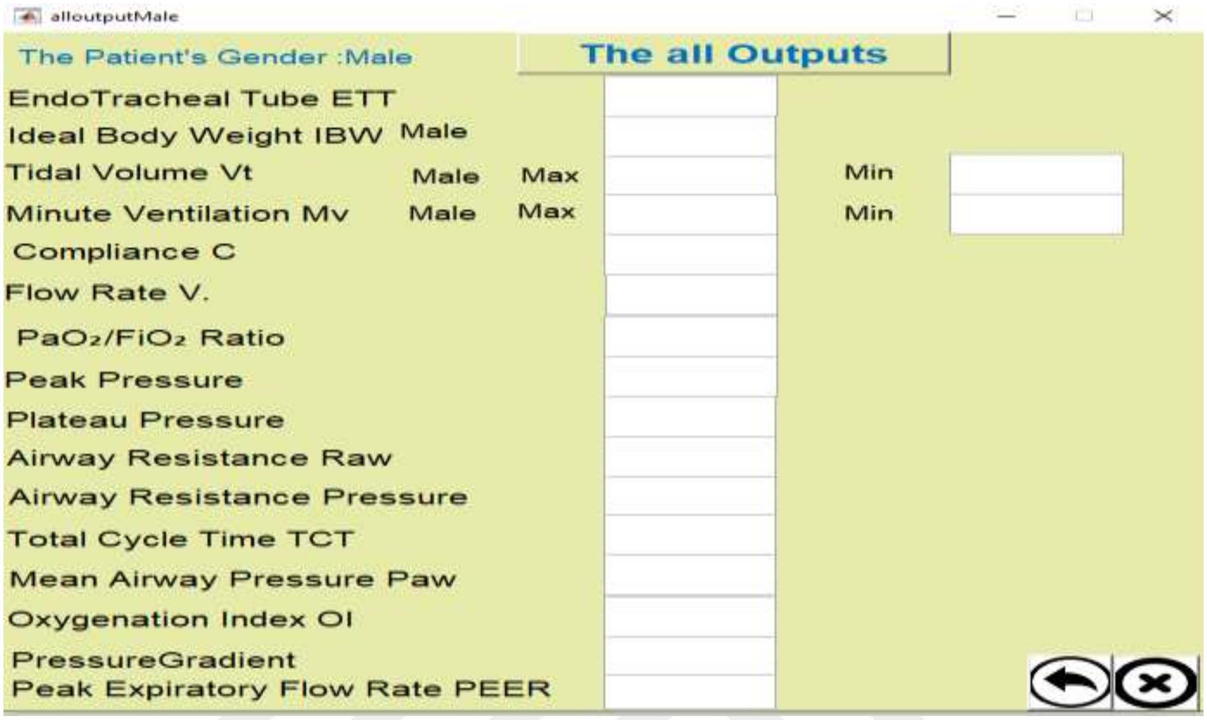
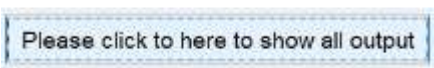


Figure 5.14. The page of the application special for shows all output parameters if the patient is male

If Patient's gender is equal Female, the page special for showing all output if click the button 

. And showing the below Figure 5.15 in this page has two buttons: The "Undo" button clicks the button to the previous page, and "Close" button then click the button close the page.

Figure 5.15. The page of the application special for shows all output parameters if the patient is female

E. Mechanical Ventilation Simulink File

The Simulink file we have a lot of parts, for example, a list of symbols used in Simulink file as shown in Figure 5.16.

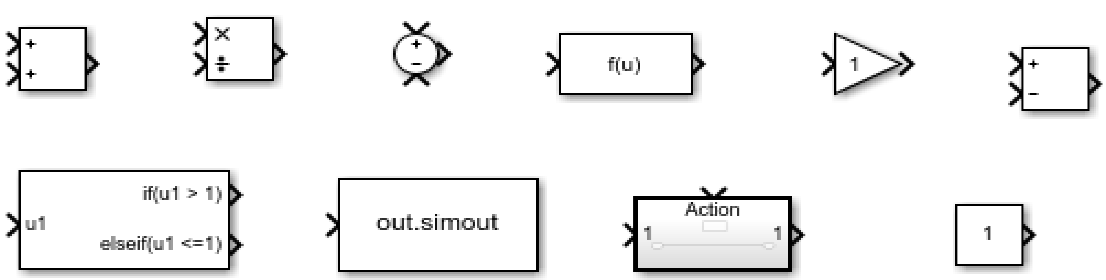


Figure 5.16. List of symbols used in Simulink file

In the research, the application has two Simulink files, one of them for female another file for male. This part of the Simulink file was calculated the total cycle in one breath and expiratory rate as shown in Figure 5.17.

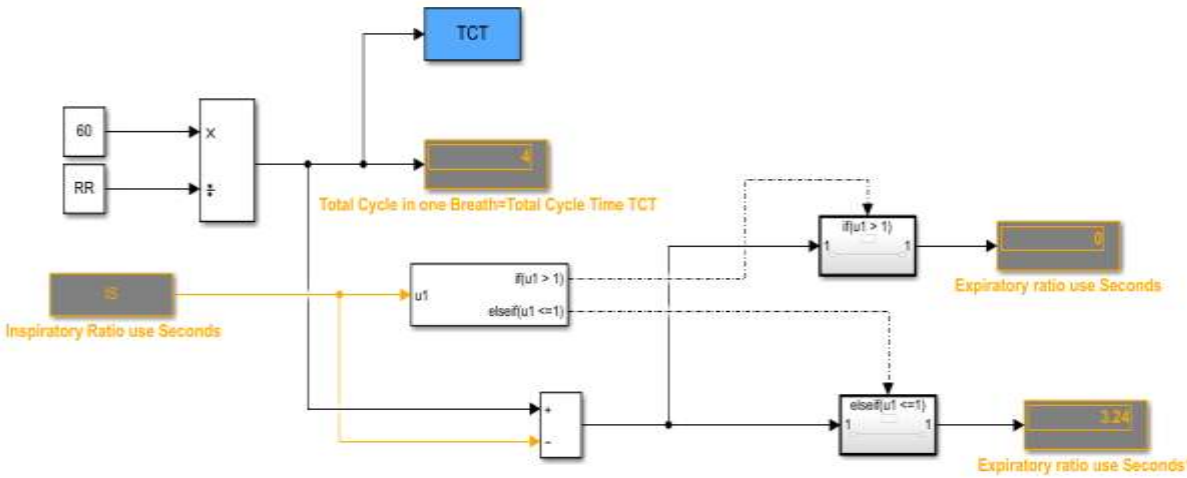


Figure 5.17. This part of the Simulink file was calculated the total cycle in one breath and expiratory rate

This part of the Simulink file to was calculated the oxygen saturation SaO_2 as shown in Figure 5.18.

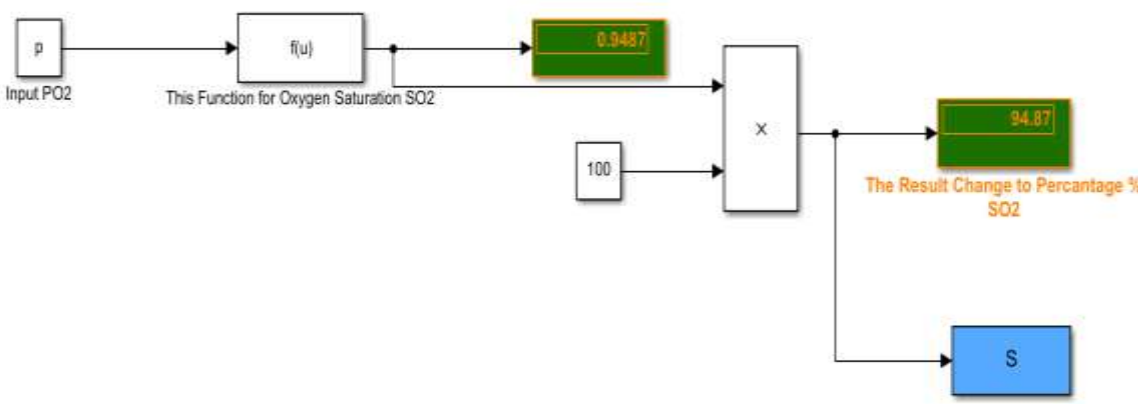


Figure 5.18. This part of the Simulink file was calculated the oxygen saturation SaO2

This part of the Simulink to was calculated the oxygen index OI and mean airway pressure Paw and P/F ratio as shown in Figure 5.19, the main part of the Simulink file as shown in Figure 5.20.

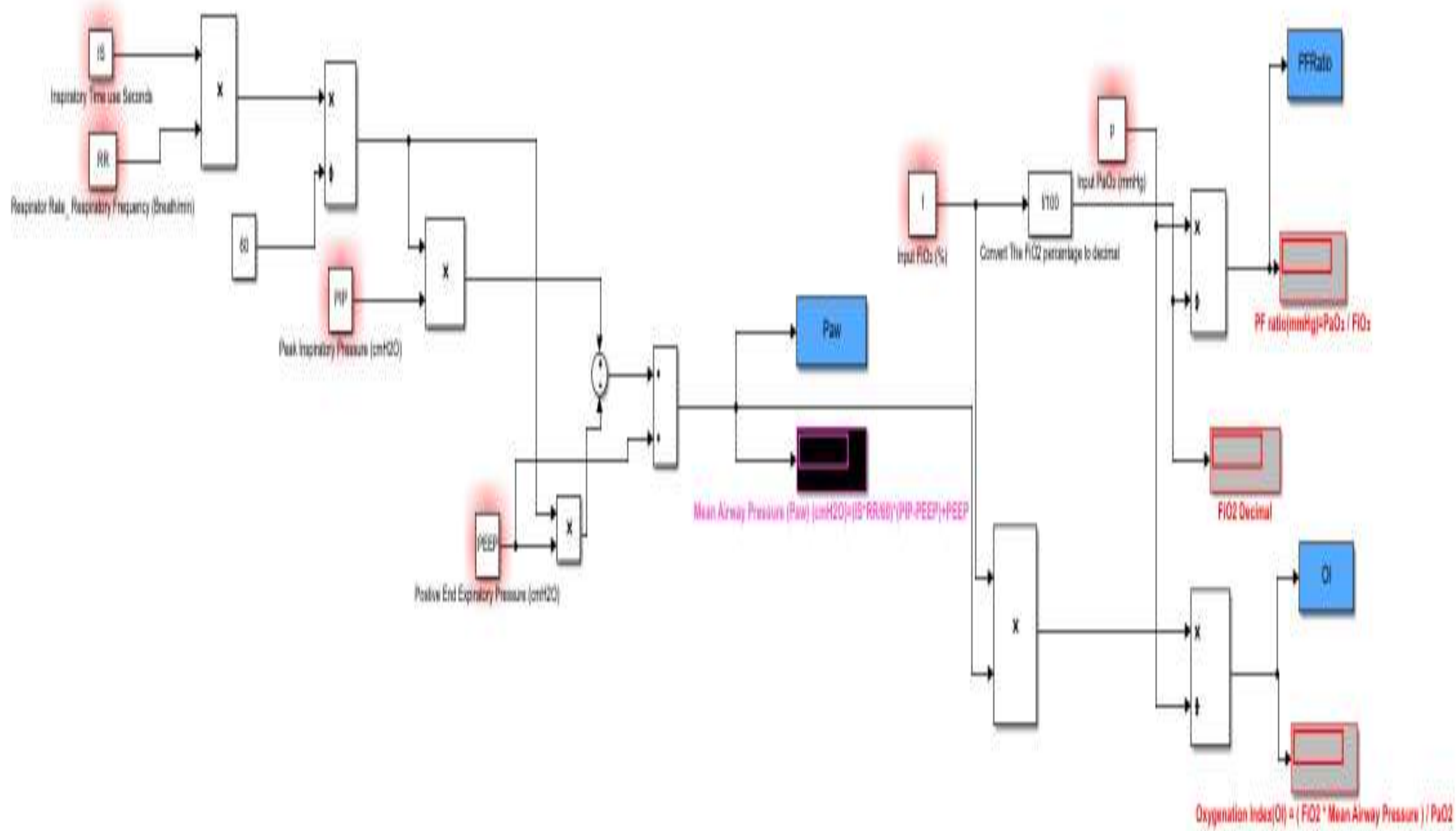


Figure 5.19. This part of the Simulink file was calculated the oxygen index OI and mean airway pressure Paw and P/F ratio

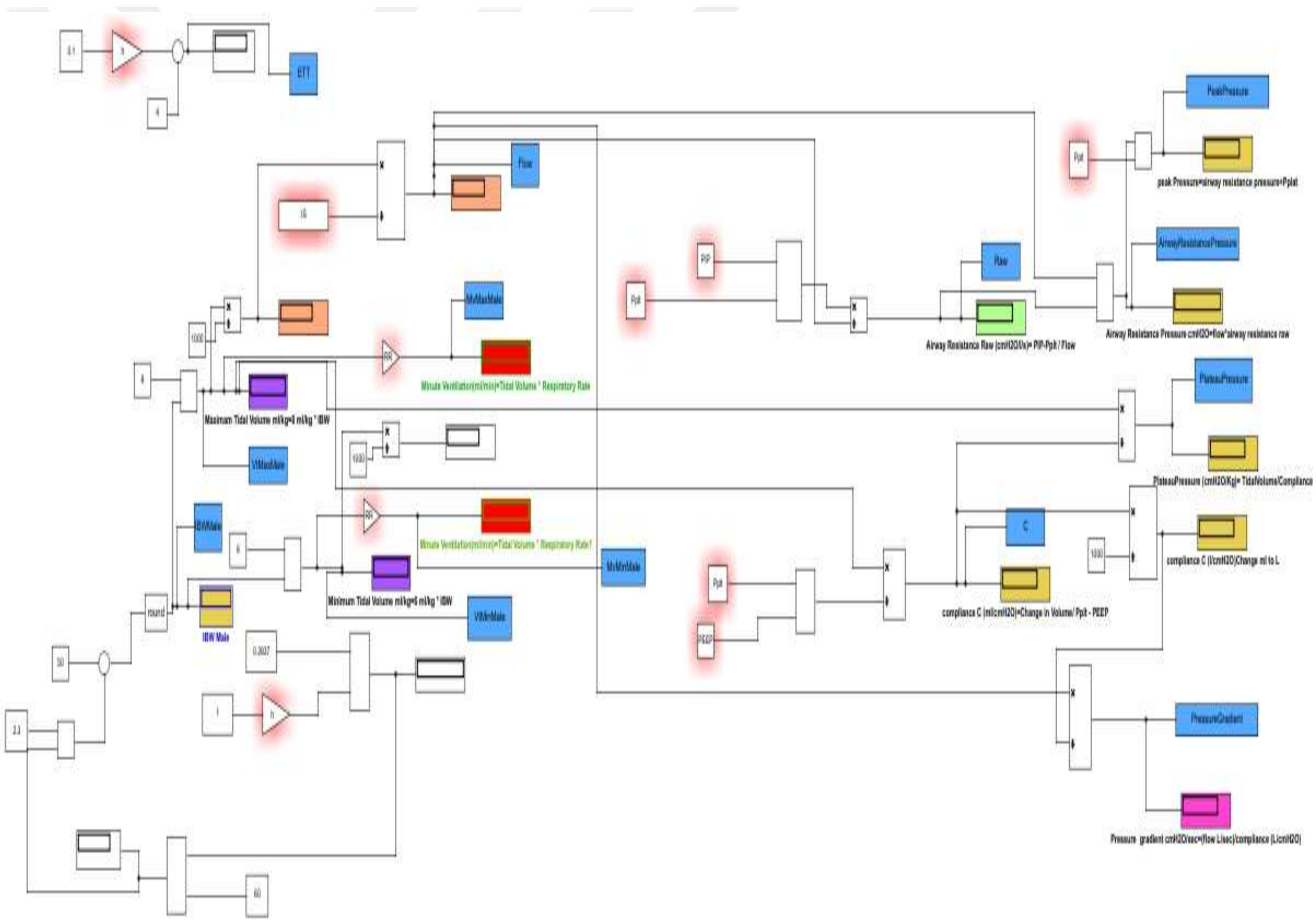


Figure 5.20. The main part of the Simulink file

5.3. Evaluation of Results

In the research, in this section describe three cases of the patient's status: The first case normal value, the second case low value and the third case high value, and show all input parameters and output parameters and all graphs.

5.3.1. Case 1: Normal Value

Whether all the value of parameters is normal, the oxygen saturation is normal, all the output variables are the normal range, the three waveforms are the normal range. In

Table **5.6**, Table 5.7 shows all input parameters and output parameters, and in theses Figure 5.23, Figure 5.24, Figure 5.25 appear the waveforms for flow rate and tidal volume, pressure.

Mechanical Ventilation Monitor in GUI MATLAB Plot Button: After the entered username and password to the login page, and open the first page the click to the “Simulate” button open the select patient file and the patient file saved in google drive after that download and select the patient file to calculate the blood pressure, pulse pressure, heart rate and percentage of oxygen in the human body, and appear the waveform for blood pressure, pulse pressure, heart rate and percentage of oxygen in the human body, and after that show the graphs and appearing the message boxes for each blood pressure, pulse pressure, heart rate and percentage of oxygen in the human body in which level it. The first time clicks the “Calculate” button open the Simulink file then calculating the operation in the Simulink-MATLAB and the second click the “Plot” button drawing the graph for pressure and tidal volume, flow rate. In the following Figure 5.21 the first page of mechanical ventilator application if a patient’s gender is male in the first case normal value. As shown in Figure 5.22 the message boxes for the first page of mechanical ventilator application if a patient’s gender is male in the first case normal value.

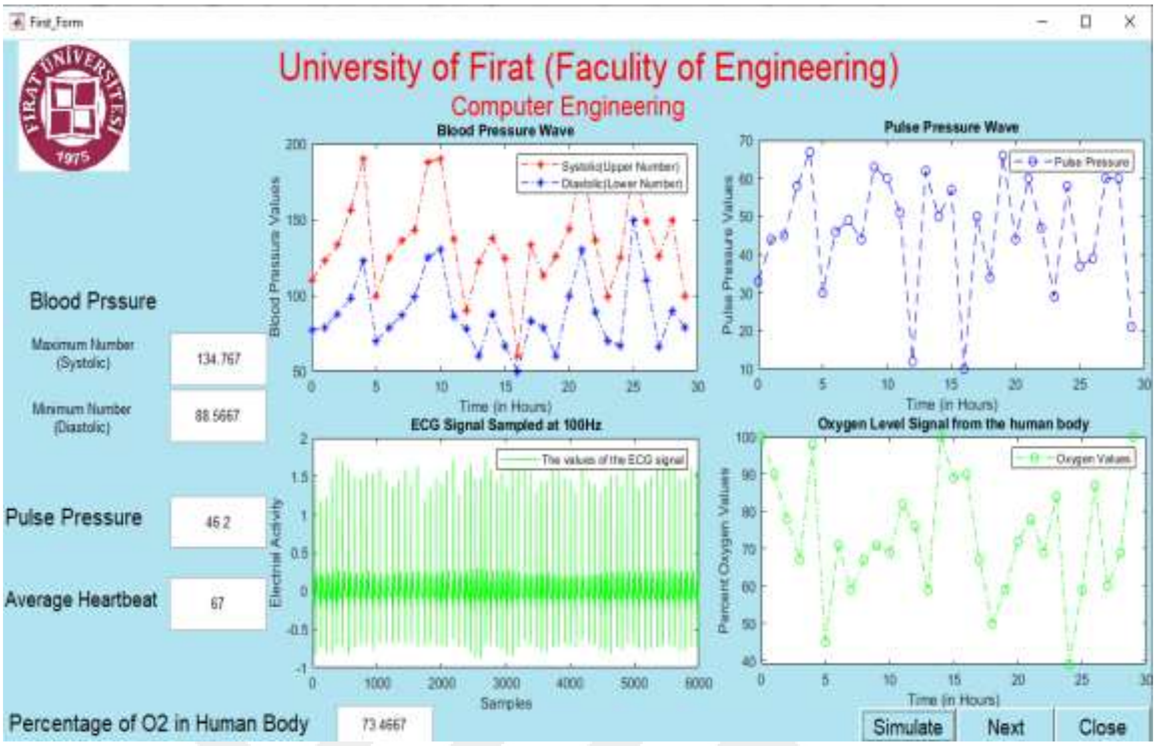


Figure 5.21. The first page of mechanical ventilator application if a patient's gender is male in the first case normal value

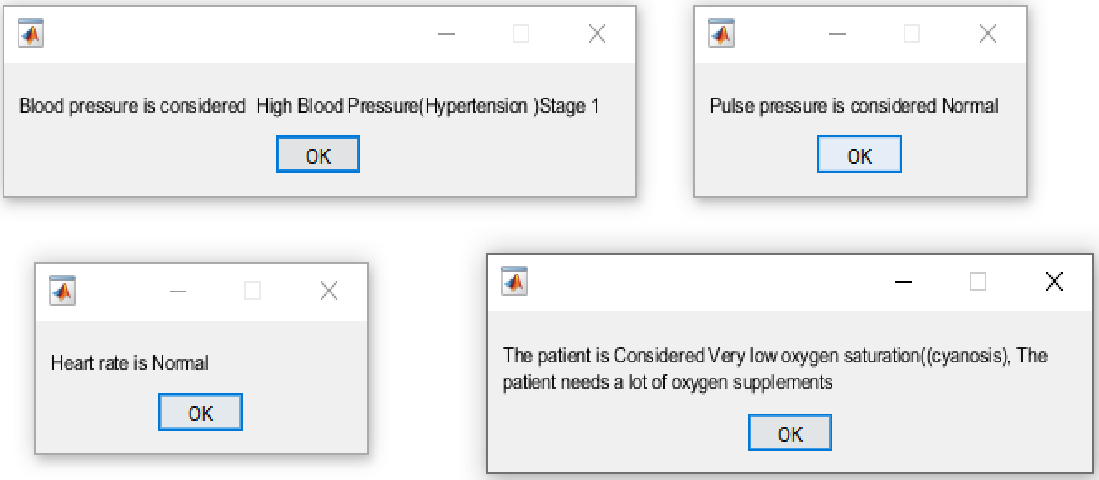


Figure 5.22. The message boxes for the first page of mechanical ventilator application if a patient's gender is male in the first case normal value

- Flow Rate: The maximum flow rate, or peak inspiratory flow rate, is the maximum flow at which the ventilator produces a fixed tidal breath capacity. Flow speeds of between 60 and 120 L/min can be provided by most modern ventilators. Flow speeds should be titrated to satisfy the inspiratory needs of the patient. the finding flow rate needs the tidal volume and inspiratory rate, the below Figure 5.23 shows the flow rate vs time waveform.

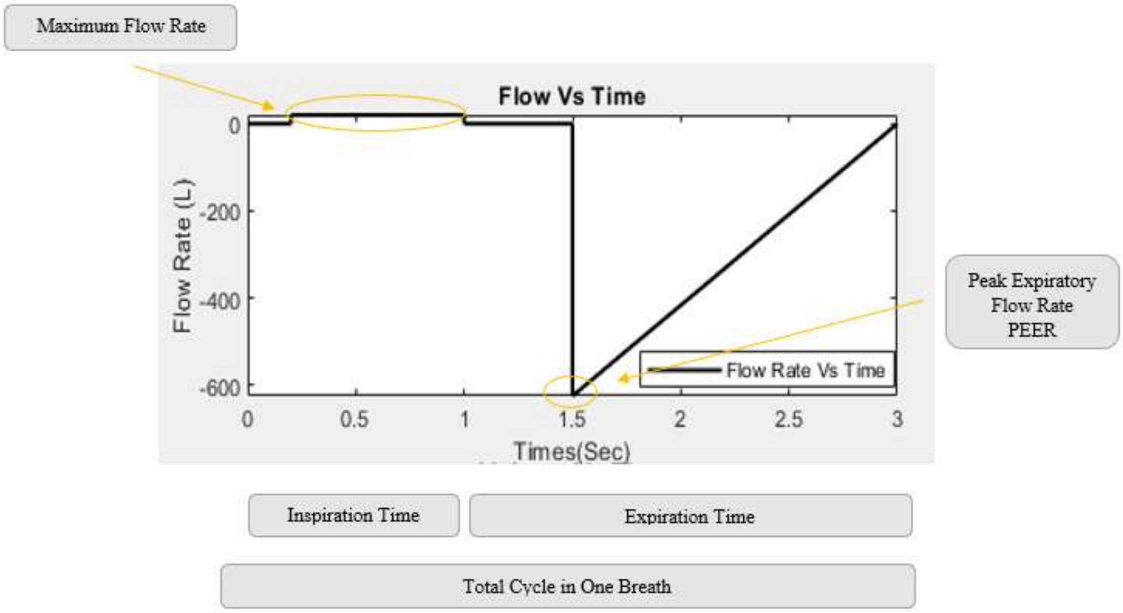


Figure 5.23. Flow vs time waveform in the first case

- Tidal Volume: Tidal volume During a breath, gas volume when inhaled or exhaled. The volume versus time waveform's full value. Full cycle time the amount of inspiratory time and expiratory time is the same as the ventilatory duration, the below Figure 5.24 shows the tidal volume vs time waveform.

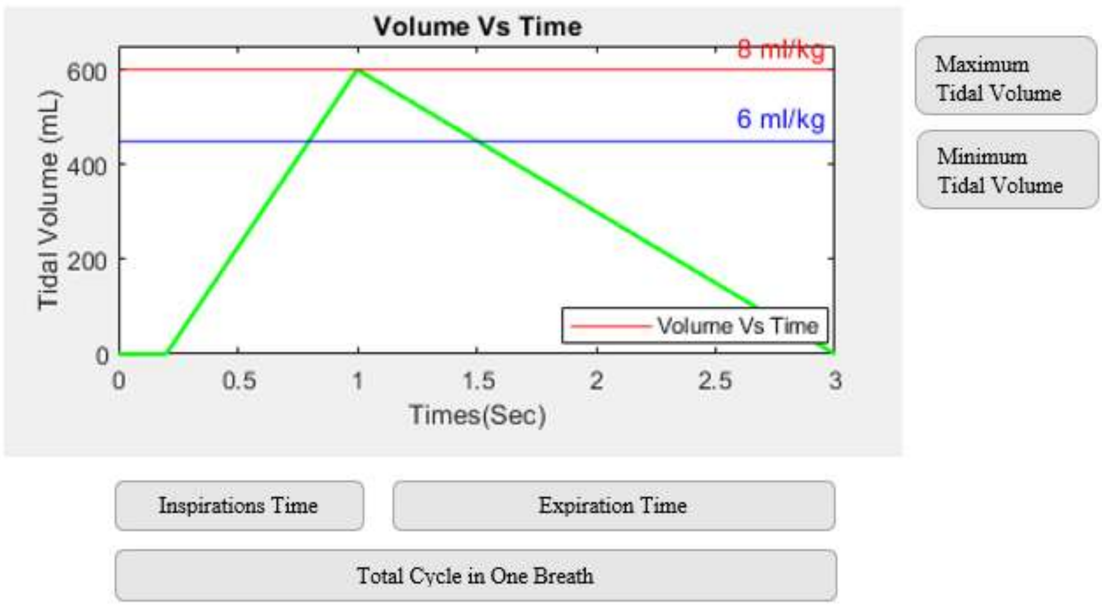


Figure 5.24. Tidal volume vs time waveform in the first case

- Pressure Waveform: A random ventilation mode is pressure support ventilation (PSV), also known as pressure support. The patient initiates each breath, and with the predetermined pressure value, the ventilator assists. The patient also controls his respiratory rate and tidal volume with assistance from the ventilator, the below Figure 5.25 shows the pressure vs time waveform.

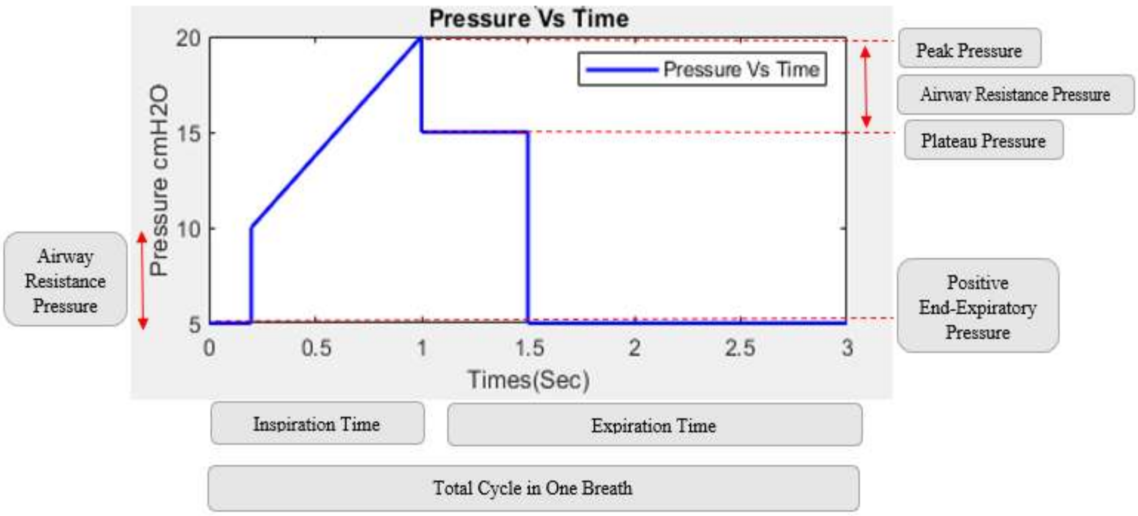


Figure 5.25. Pressure vs time waveform in the first case

5.3.2. Case 2: Low Value

Whether all the value of parameters is low, the oxygen saturation is low, all the output variables are the low range, the three waveforms are the abnormal range. In the following Table 5.8 shows all input parameters and output parameters, in these Figure 5.28, Figure 5.29, Figure 5.30 appear the waveforms for flow rate and tidal volume, pressure. In the following Figure 5.26 the first page of mechanical ventilator application if a patient's gender is female in the second case low value. As shown in Figure 5.27 the message boxes for the first page of mechanical ventilator application if a patient's gender is female in the second case low value.

Table 5.8. Monitor displaying all the input and output parameters if a patient's gender is female in the second case low value

Input Parameters			Normal Ranges	Output Parameters		Normal Ranges
Test No.				4		
Blood Pressure	Systolic (Upper No.)	152.767	Systolic less than120 and Diastolic less than 80	SaO2	84.9904	From 90 to 100
	Diastolic (Lower No.)	90.9667		Maximum Mv	2280	From 0 to 8000
Pulse Pressure		61.8	From 40 to 60	Minimum Mv	1710	From 0 to 4000
Heartbeat		67	From 60 to 100	Flow Rate	0.456 L/Sec * 60 Sec/1 min=27.36	From 60 to 120
Percentage of O_2 in the human body		75.0667	From 90 to 100	ETT	20.5	Depending on the patient
Height		165	Depending on the patient	IBW	57	Depending on the patient
Gender		Female	Depending on the patient	TCT	12	From 0 to 5
Age		30	Depending on the patient	OI	0.8533	From 0 to 5
Ppalt		8	From 0 to 30	Maximum Vt	456	Male From 0 to 780 Female From 0 to 500
RR		5	From 12 to 16	Minimum Vt	342	Male From 0 to 570 Female From 0 to 550
IS		1	From 0 to 1	P/F Ratio	312.5	Greater than 400
FiO2		16	From 21% to 100%	PEER	448.68	From 400 to 700
PaO2		50	From 75 to 100	Pressure Gradient	6	From 2 to 14
PEEP		2	From 3 to 5	Peak Pressure	10	From 18 to 25
PIP		10	From 0 to 30	Paw	2.6667	From 10 to 15
				Raw	4.386	From 0 to 2.8
				Pplat	6	From 0 to 35
				Compliance	76	From 0 to 200 cm
				Airway Resistance Pressure	2	From 2 to 3 cm

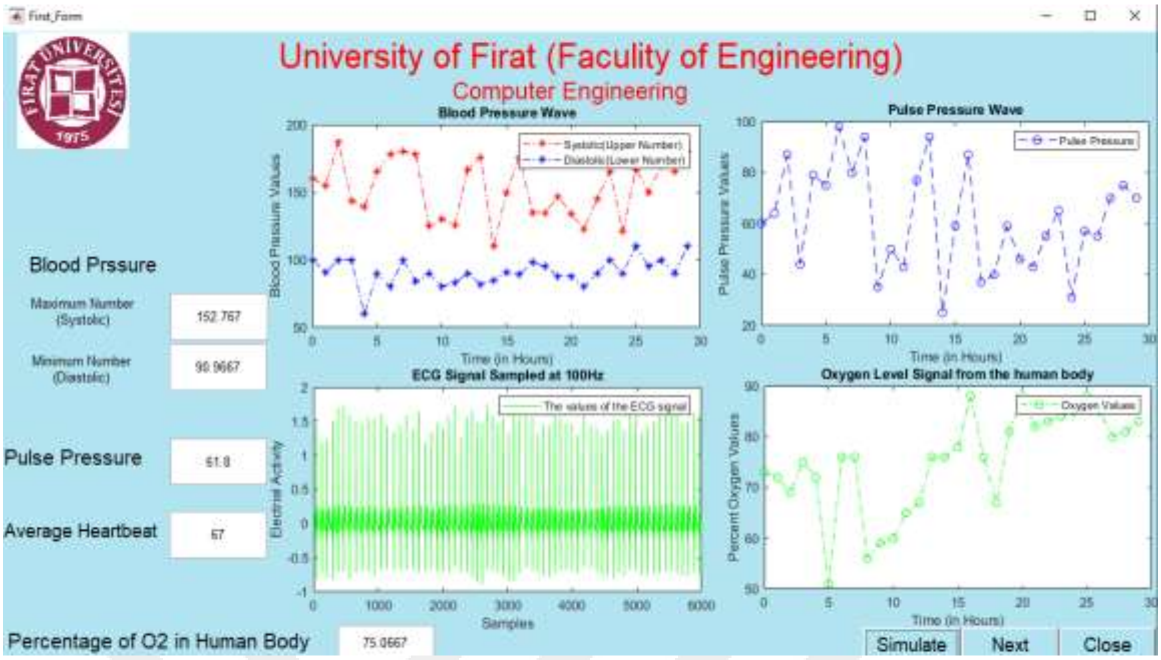


Figure 5.26. The first page of mechanical ventilator application if a patient's gender is female in the second case low value

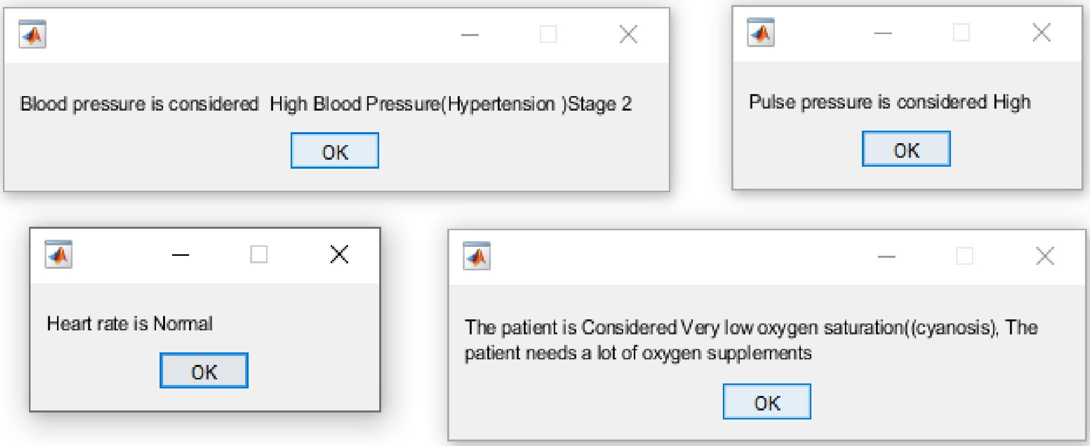


Figure 5.27. The message boxes for the first page of mechanical ventilator application if a patient's gender is female in the second case low value

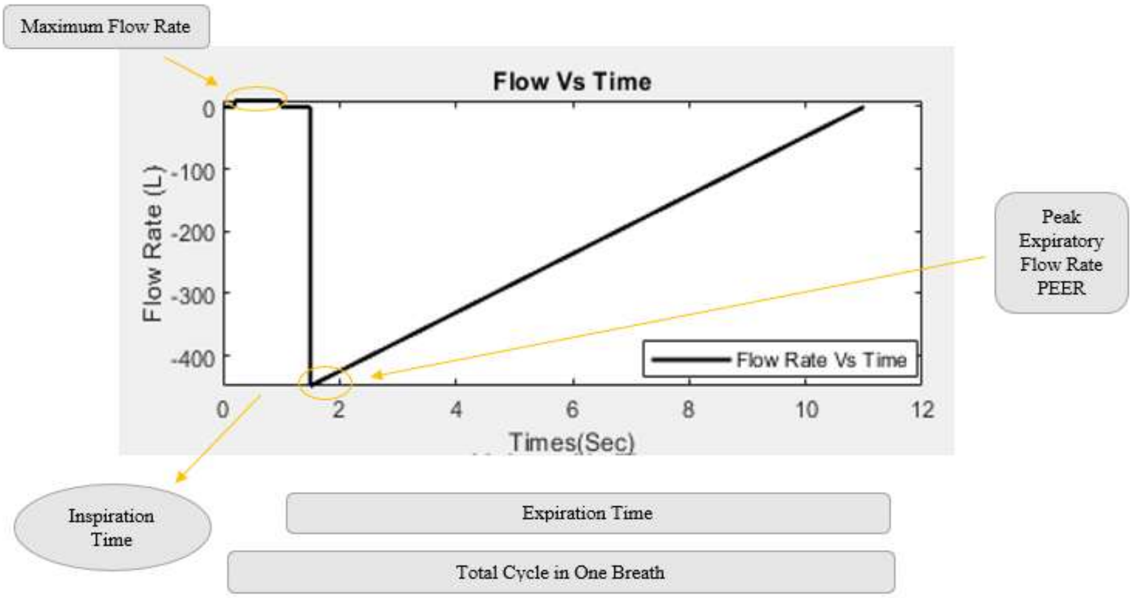


Figure 5.28. Flow vs time waveform if a patient's gender is female in the second case low value

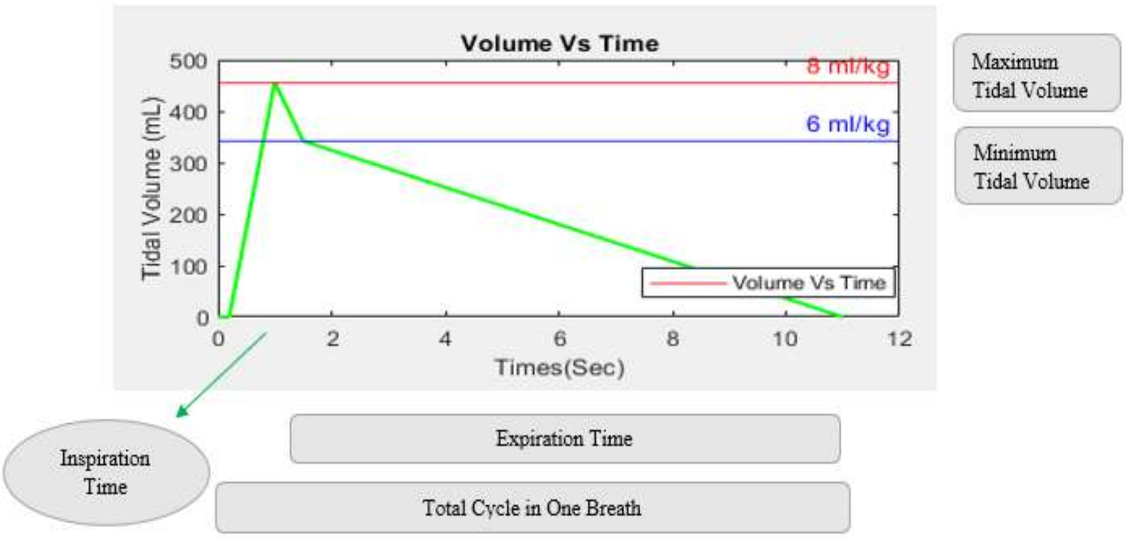


Figure 5.29. Tidal volume vs time waveform if a patient's gender is female in the second case low value

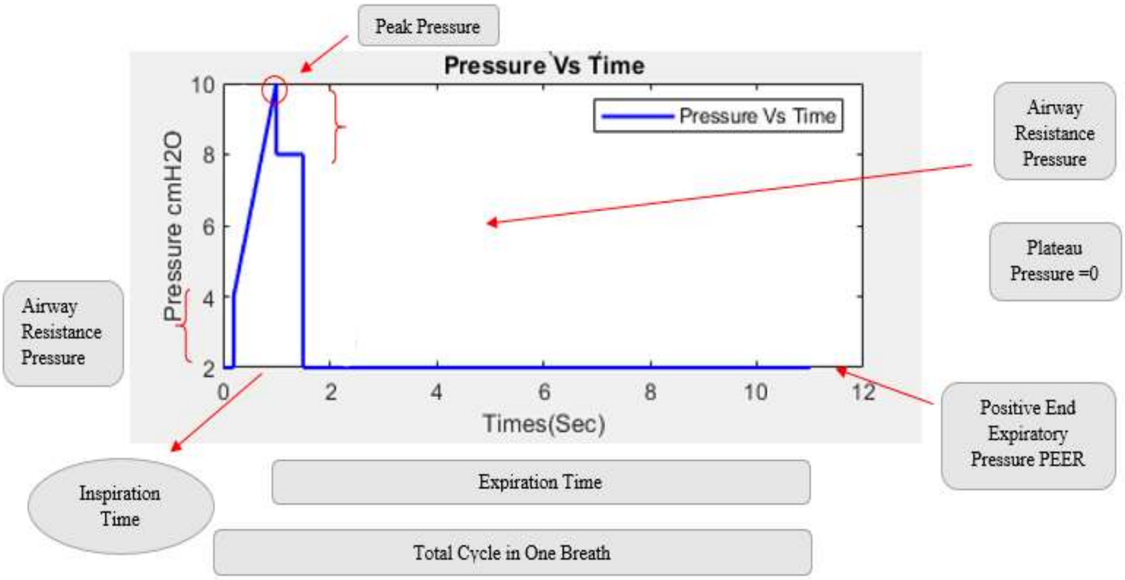


Figure 5.30. Pressure vs time waveform if a patient's gender is female in the second case low value

5.3.3. Case 3: High Value

Whether all the value of parameters is high, the oxygen saturation is normal, all the output variables are the high range, the three waveforms are the abnormal range. In the following

Table 5.9. Monitor displaying all the input and output parameters if a patient's gender is male in the third case high value shows all input parameters and output parameters, in these Figure 5.33, Figure 5.34, Figure 5.35 appear the waveforms for flow rate and tidal volume, pressure. In the following Figure 5.31 the first page of mechanical ventilator application if a patient's gender is male in the third case high value. As shown in Figure 5.32 the message boxes for the first page of mechanical ventilator application if a patient's gender is male in the third case high value.

Table 5.9. Monitor displaying all the input and output parameters if a patient's gender is male in the third case high value

Input Parameters			**Normal Ranges**	**Output Parameters**		**Normal Ranges**
Test No.					**3**	
Blood Pressure	Systolic (Upper No.)	128.333	Systolic less than 120 and Diastolic less than 80	SaO2	97.7465	From 90 to 100
	Diastolic (Lower No.)	73		Maximum Mv	8784	From 0 to 8000
Pulse Pressure		55.3333	From 40 to 60	Minimum Mv	6588	From 0 to 4000
Heartbeat		67	From 60 to 100	Flow Rate	0.488 L/Sec * 60 Sec/1 min=29.28	From 60 to 120
Percentage of O2 in the human body		73.7	From 90 to 100	ETT	20.5	Depending on the patient
Height		165	Depending on the patient	IBW	61	Depending on the patient
Gender		Male	Depending on the patient	TCT	3.3333	From 0 to 5
Age		30	Depending on the patient	OI	15.6	From 0 to 5
Ppalt		25	From 0 to 30	Maximum Vt	488	Male From 0 to 780 Female From 0 to 500
RR		18	From 12 to 16	Minimum Vt	366	Male From 0 to 570 Female From 0 to 550
IS		1	From 0 to 1	P/F Ratio	125	Greater than 400
FiO2		80	From 21% to 100%	PEER	563.52	From 400 to 700
PaO2		100	From 75 to 100	Pressure Gradient	10	From 2 to 14
PEEP		15	From 3 to 5	Peak Pressure	30	From 18 to 25
PIP		30	From 0 to 30	Paw	10	From 10 to 15
				Raw	19.5	From 0 to 2.8
				Pplat	10	From 0 to 35
				Compliance	48.8	From 0 to 200 cm
				Airway Resistance Pressure	5	From 2 to 3 cm

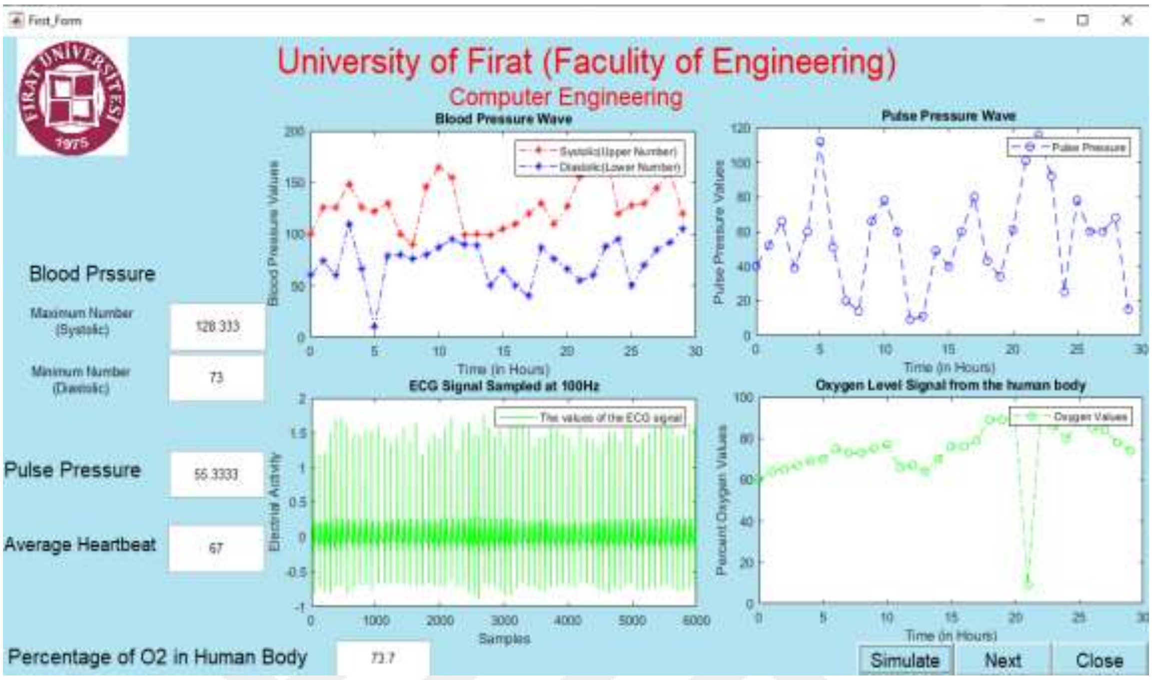


Figure 5.31. The first page of mechanical ventilator application if a patient's gender is male in the third case high value

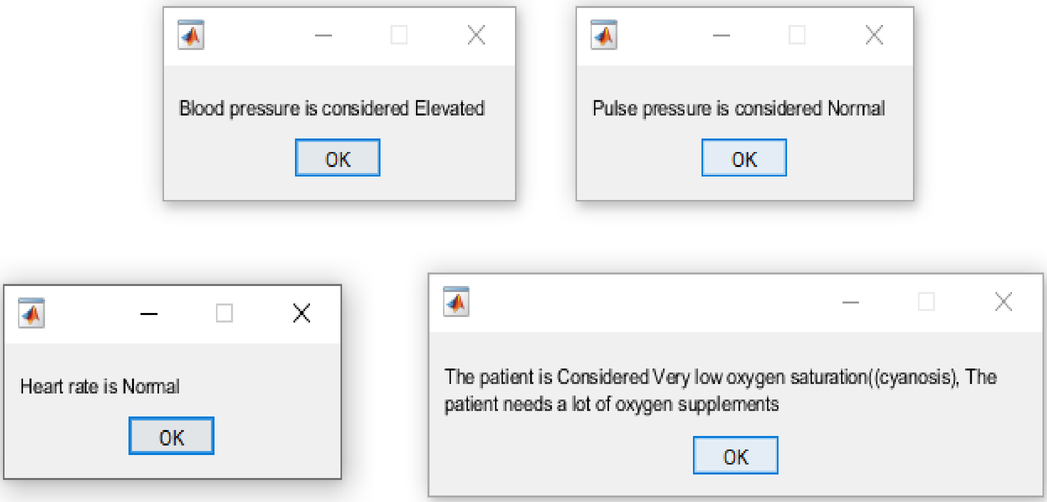


Figure 5.32. The message boxes for the first page of mechanical ventilator application if a patient's gender is male in the third case high value

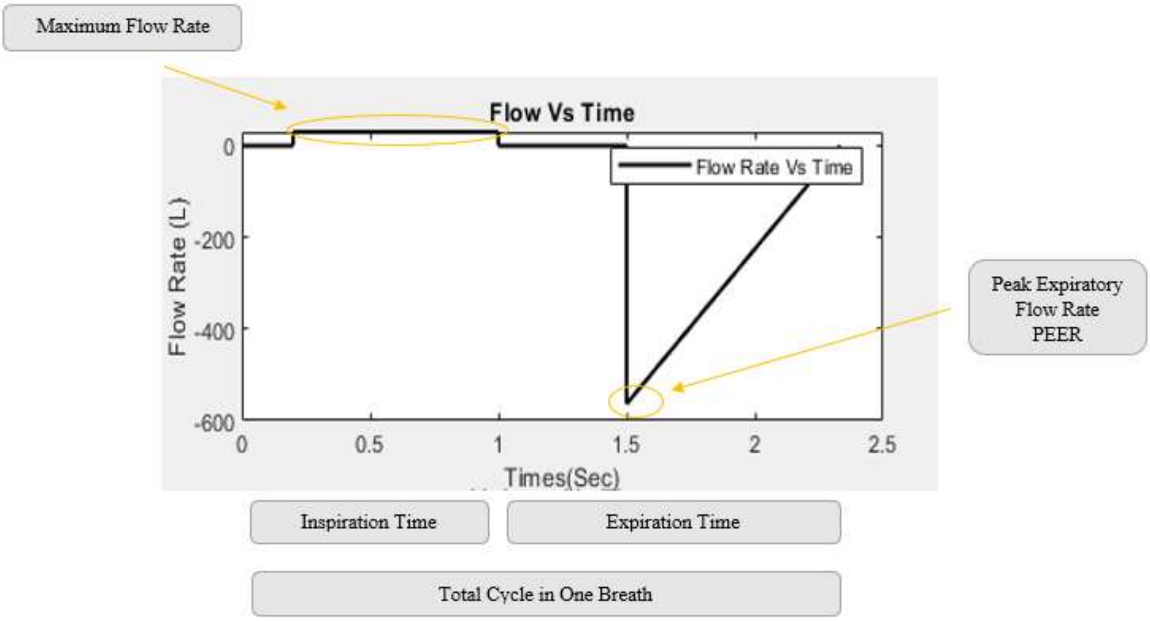


Figure 5.33. Flow rate vs time waveform if a patient's gender is male in the third case high value

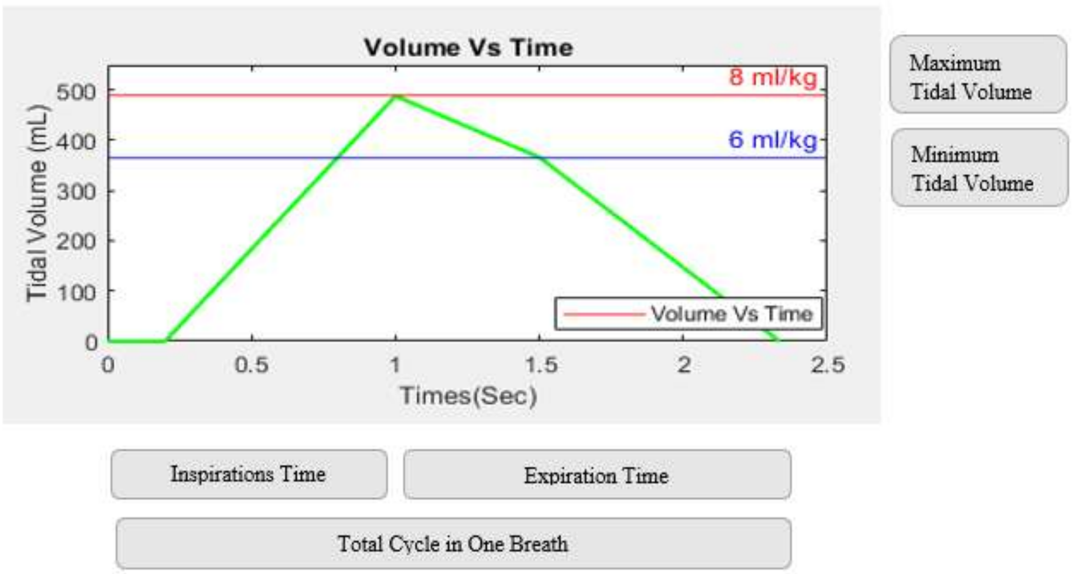


Figure 5.34. Tidal Volume vs time waveform if a patient's gender is male in the third case high value

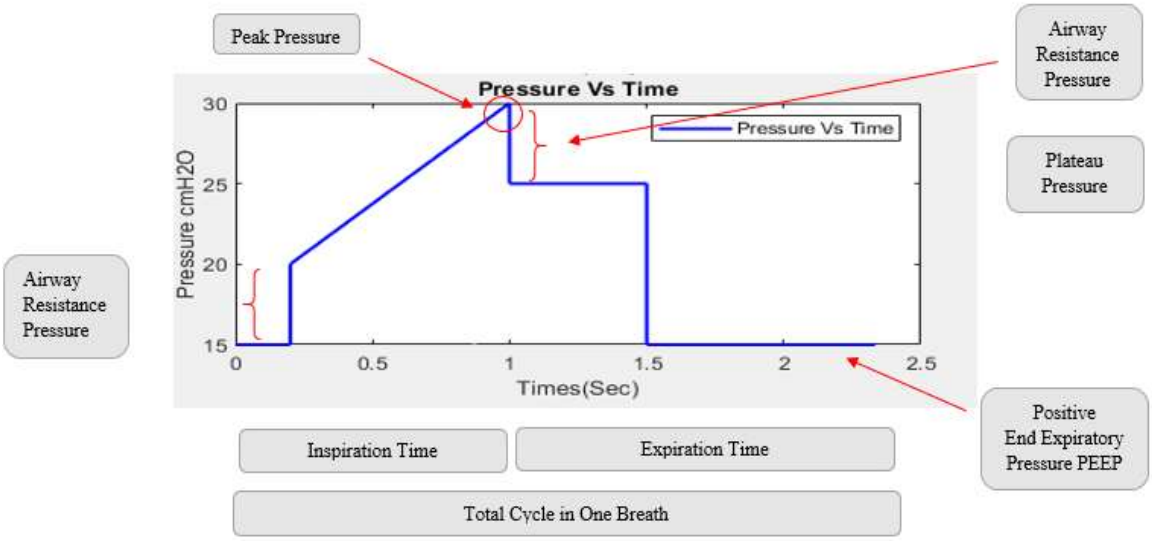
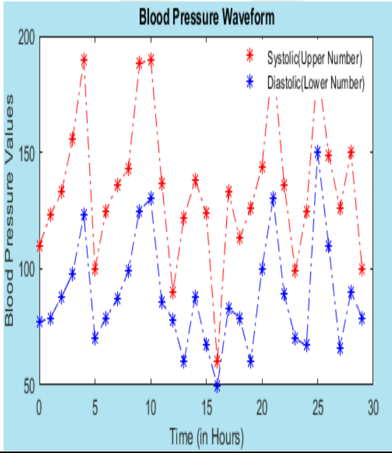
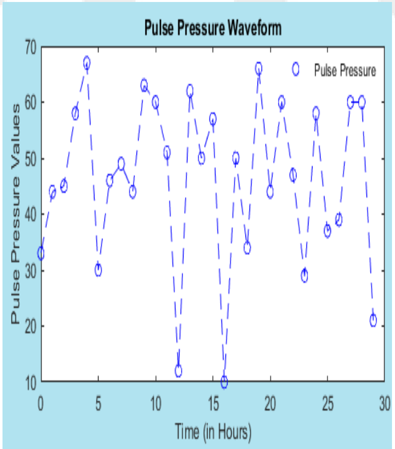
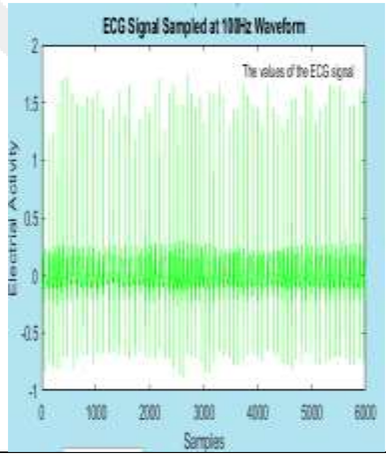
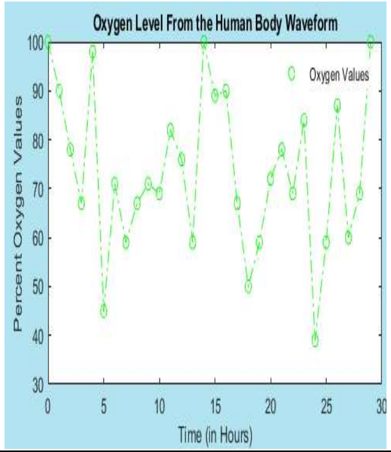
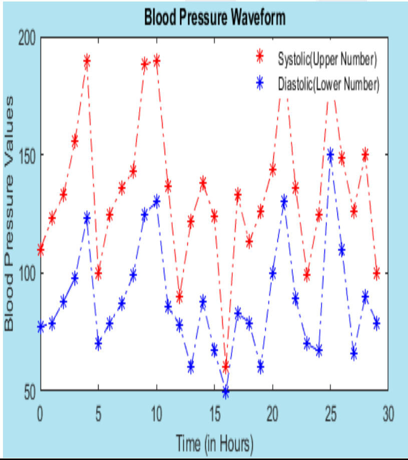
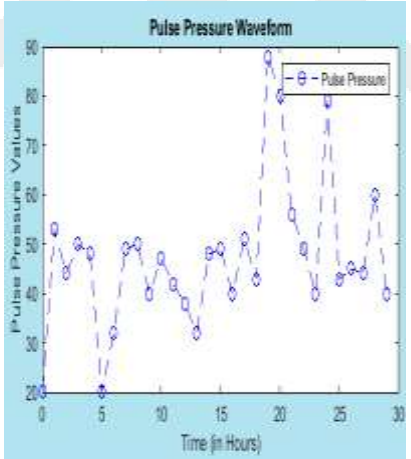
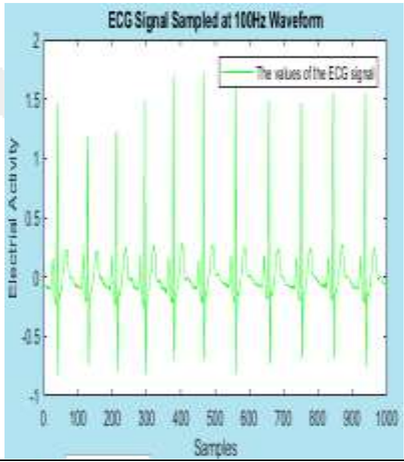
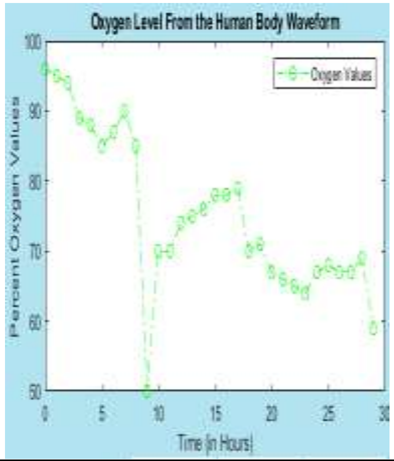


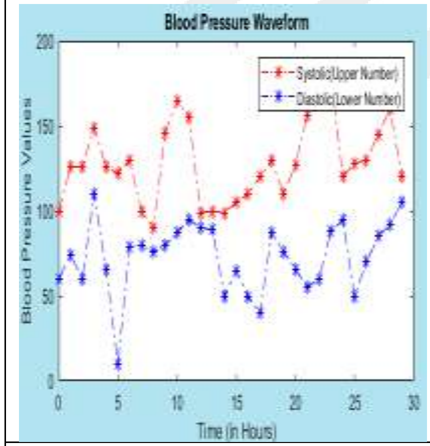
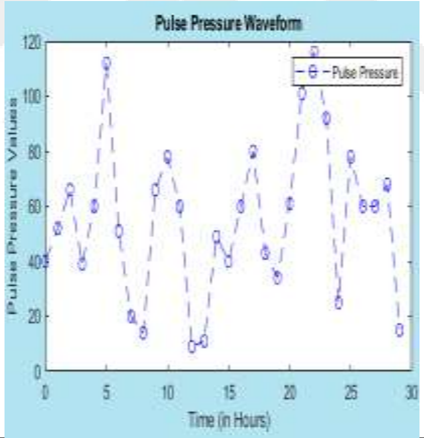
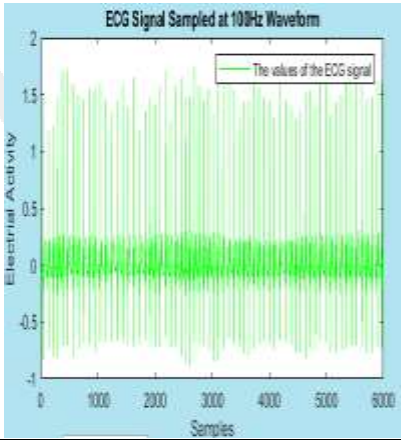
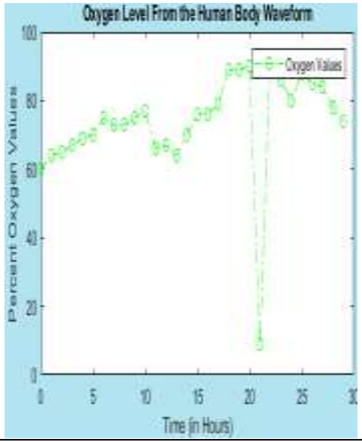
Figure 5.35. Pressure vs time waveform if a patient's gender is male in the third case high value

In the following Table 5.10 comparing all graph and result for each patient. In this table has three tests for patient appear all graph and result of the graph with the number and describe all case.

Table 5.10. Compares the whole graph and results from

<table>
<tr><th>Test No.</th><th>Blood Pressure Waveform</th><th>Pulse Pressure Waveform</th><th>ECG Signal Sampled at 100Hz Waveform</th><th>Percentage of Oxygen in the Human Body Waveform</th></tr>
<tr><td rowspan="2">1</td><td>
</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>Systolic= 134.767
Diastolic= 88.5667</td><td>Pulse Pressure= 46.2</td><td>Heartbeat= 67</td><td>Oxygen Percentage= 73.4667</td></tr>
<tr><td>Results</td><td>Blood pressure is considered High (Hypertension) Stage 1</td><td>Pulse pressure is considered Normal</td><td>Heart rate is Normal</td><td>The patient is Considered Very Low Oxygen Saturation(cyanosis), The patient needs a lot of oxygen supplements</td></tr>
</table>

Test No.	Blood Pressure Waveform	Pulse Pressure Waveform	ECG Signal Sampled at 100Hz Waveform	Percentage of Oxygen in the Human Body Waveform
2				
	Systolic= 135.667 Diastolic= 88.3333	Pulse Pressure= 47.3333	Heartbeat= 66	Oxygen Percentage= 75.3
Results	Blood Pressure is considered High (Hypertension) Stage 1	Pulse pressure is considered Normal	Heart rate is Normal	The patient is Considered Very Low Oxygen Saturation(cyanosis), The patient needs a lot of oxygen supplements

Test No.	Blood Pressure Waveform	Pulse Pressure Waveform	ECG Signal Sampled at 100Hz Waveform	Percentage of Oxygen in the Human Body Waveform
3				
	Systolic= 128.333 Diastolic= 73	Pulse Pressure= 55.3333	Heartbeat= 67	Oxygen Percentage= 73.7
Results	Blood Pressure is considered Elevated	Pulse pressure is considered Normal	Heart rate is Normal	The patient is Considered Very Low Oxygen Saturation(cyanosis), The patient needs a lot of oxygen supplements

In the research using MATLAB, in the MATLAB environment, the program was applied (MATLAB R2020a on a PC running Microsoft Windows 10 version pro). There are some benefits of the current MATLAB implementation of the simulator:

With a comprehensive library of MATLAB toolboxes for computational analysis and design, the model is easily integrated. This is useful for model validation work and for determining optimal ventilator settings to be carried out in the following phases of this project. A simple interface for the broader management population is provided by the easy availability of applications and control toolboxes.

The MATLAB Simulator provides quick storage and access to all the involved variables in the simulation, the only limitation is the machine memory available. This makes it possible to log and track minor differences in any chosen variable for further study.

The explicit high-level MATLAB code can be quickly amended and screened, so any improvements are easy for the user to manage.

If you need to access the patient’s file somewhere, all patient’s backup in the GOOGLE DRIVE using the cloud, they don't have to use much memory on the computers.

The results obtained from running simulations are stored in a MAT format that makes it easy for the data to be displayed and converted to spreadsheet applications such as MICROSOFT EXCEL.

The results of running simulations are stored in a MAT format that makes it easy for the data to be viewed and converted to table applications such as MICROSOFT ACCESS.

Since the MATLAB simulator is based on a GUI (Graphical User Interface), manually adjusting values and configurations during simulations is not as simple but the results can also be controlled by changing all input parameters using the GUI page. The current scope of the simulator, however, is for theoretical and computational research and not for real-time study, so this is not supposed to be a major concern. Finally, it is important to find out that both simulators can work together well. Inside the code, the MATLAB simulator would allow simpler access to any variable.

6. CONCLUSION

In this thesis, create a digital twin for mechanical ventilator using the cloud for saving the patient’s file, In the research using Google Drive offers an online file save and access to files from either device, tablet or device via a cloud-based storage system. You can easily upload and edit files with Drive on your computer or mobile device. Cloud storage uses data centers and huge database servers that hold the data physically and make it accessible to users digitally through the Internet. Users can upload, store and retrieve information remotely if needed. Cloud computing ensures that computational services, in particular data storage and computing power, are accessible on-demand, without direct active user management. The term is commonly used to describe data centers for many internet users. Cloud Users, as well as companies interested in technology, cloud computing has several chances, speed of cost savings, global availability, efficiency, reliability, data recovery, access, security. And use intelligent systems are sophisticated technical devices that understand the world around them and respond to them. The area of intelligent systems also focuses on the relationship between these systems in evolving physical and social conditions with human users. They all describe digital twin uses in many sectors but the healthcare sector using the digital twin is very little because the intelligent healthcare systems were very difficult systems and a lot of functions it is very complicated. In this research explains all the details about the digital twin very clearly, and how to create a digital twin for the mechanical ventilator, an artificial ventilation mathematical model of a mechanical ventilator portrays its actions. This research aims to construct and simulate a mechanical ventilator mathematical model. This mathematical model illustrates the respiratory activities and, during mechanical ventilation, an important controlled parameter. The application uses the login page to login to the application and loaded the patient file in the Google Drive appears average for blood pressure, pulse pressure, heartbeat and percentage of oxygen in the human body. Monitored waveforms for average blood pressure, pulse pressure, heartbeat and percentage of oxygen in the human body, each one sample get in one hour, the total samples are 30. The first understanding and describe all parameters related to the mechanical ventilators and using the mathematical model to create a digital twin for the mechanical ventilator using the MATLAB, with Simulink MATLAB toolbox, all the models were planned and executed. This is a beneficial paradigm of artificial ventilation for the simple ventilation parameter analysis, in the MATLAB using the GUI and Simulink create a model for the medical systems in the Simulink and make a monitor like a screen for mechanical ventilator use the GUI for input parameters and calculate all operations in the Simulink file, it has two types of process male and female, after that the complete operation in the Simulink file and appears all output parameters and mechanical ventilator waveforms, the waveforms for tidal volume, flow rate and pressure, and all output can be saved in the file to compare the normal ranges for each parameter. The most important task gauges the oxygen saturation in the human body and shows the warns describe the patient's state which percentage need oxygen. A basic analysis of respiratory control models can be performed with the assistance of the implemented simulator. It is possible to extend the proposed model and simulator to the simulation of a mechanical ventilation system. With the optimized respiratory waveforms and breathing pattern obtained from the simulator, it is also possible to create a mechanical ventilation system. This simulator is also able to reflect a respiratory mechanic by changing some input variables such as PIP, PEEP, Pplat, PaO_2, FiO_2, gender, height, inspiration rate and the respiratory rate which is monitored in tidal volume, flow rate, pressure waveforms. The simulator obtained offered a clear environment for testing and tracking and other parameters for artificial ventilation (tidal volume, flow rates and pressure). In general, this thesis provides a through the introduction for mechanical respirator modelling and control design, describe all waveforms.

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RESEARCH EXPERIENCES

- ✓ Laboratory Instruments you use, such as test systems etc.
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