PE-Predictor

STEM High School for Boys – 6th of October

Grade 12 | 2023-2024

Group: 10304

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Chapter I

Present and Justify a Problem and Solution Requirements

Egypt Grand Challenges

introduction

Introduction:

During Egypt's growth and development over the years, it began to encounter many problems. These significant problems are called (Egypt Grand Challenges) as shown in figure (1). These challenges can lead to each other; thus they are closely related. For instance, the lack of recycling represents a major problem that is a fundamental cause of pollution. This pollution that is an impact of recycling shortage can cause many different diseases, which causes deterioration of public health.

Figure 1: Egypt's Grand Challenges

Another example, the lack of alternative energies usage, which opens a way for fossil fuels to continue being used, thus increasing the climate change by increasing the greenhouse gases emissions, and increases pollution. This pollution can represent a problem to agricultural areas. Lack of alternative energies can also present shortage and inefficiency of industrial bases; as fossil fuels are non-renewable resources that must not be used as the primary source of energy.

Thus, Egypt is continuously trying to solve these challenges in the future by putting an improvement plan that will reduce their bad effects on the environment and economy.

Working to eradicate public health issues

Public health is one of several issues Egypt is now dealing with. Numerous issues, including inadequate budget, poor services, a lack of medical equipment, and a lack of skilled staff, plague the public health system. Only 1.5% of the nation's GDP is allotted to public health spending, which is a low level of government investment in the public system. According to WHO, the under-five mortality rate is 19.46 per 1000 live births. Egypt is suffering from a outspread of various diseases, most notably, Hepatitis C.

In Egypt, HCV is a significant endemic medical health issue with long-term repercussions. An Egyptian demographic health study undertaken in 2008 found that 14.7% of the population was infected, making it the highest prevalence in any population in the world. The survey used a representative sample of the nation, including both urban and rural areas. Infection rates can be significantly higher, at about 26% and 28%, respectively, in the Nile Delta and Upper Egypt. This results in an estimated 170,000 new cases each year to add to the 11.5 million patients suffering from the condition, with incidence rates ranging from 2 to 6 per 1000 per year. In 2013, 7.3% of the population was estimated to have viremic HCV according to more recent epidemiological modeling studies that were undertaken to determine the disease burden. This is primarily caused by death in older age groups, where infection prevalence is higher. In Egypt in 2014, there were reportedly 125,000 new cases of viremia detected per year; 10% had chronic hepatitis, 30% had compensated cirrhosis, and 60% had decompensated cirrhosis or HCC. the number of patients in various disease stages, such as chronic hepatitis (METAVIR stages F0-F3), compensated cirrhosis (F4), decompensated cirrhosis, HCC, and liver transplant. CDC reported that hepatitis has accounted for 2% of deaths in 2010 with cirrhosis, an advanced stage of hepatitis, accounting for 9%.

Since then, the WHO and other organizations have backed the Egyptian Ministry of Health's proposal for a new national strategy to combat the HCV epidemic in Egypt. The program seeks to treat 300,000 patients a year, with costs split between the Egyptian Ministry of Health (38%), the Egyptian Health Insurance Organization (51%), private payments (3%), and lastly cash payments from patients (8%).

Causes:

Pollution

Air pollution can cause a variety of ailments, ranging from moderate headaches and dizziness to decreased energy, mild itching of the eyes, nose, mouth, and throat, but it can also result in potentially more serious problems. The most prevalent of them are respiratory conditions like asthma attacks, Chronic Obstructive Pulmonary Disease-COPD, decreased lung function, and pulmonary cancer, which is triggered by a number of carcinogen chemicals that are inhaled and enter the body.

Overpopulation

Overpopulation can affect public health in multiple ways. Overpopulation leads to the government's incapacity to expand and improve healthcare facilities for the treatment and prevention of various diseases like malaria, AIDS/HIV, and so on. It can also contribute highly to the outspread of diseases.

Lack of awareness

People are more inclined to go for screenings, testing, and checkups when they are aware of a condition and its symptoms. Lack of knowledge about diseases or available choices for screening and treatment is a significant impediment to optimal health. The Central Agency for Public Mobilization and Statistics in Egypt estimates that Egypt's poverty rate for the 2019–2020 academic year was 29.7%, with higher concentrations in rural areas. The illiteracy rate in Egypt in 2017 was 28.8%, according to the World Bank and UNESCO, with higher percentages among women and people over 65. The 2019 Global Burden of Disease study indicated that Egypt has a score of 55 on the universal health coverage index in terms of access to healthcare (a scale of 0 to 100).

Impacts:

Increasing death rates

The most obvious consequence of the deterioration of public health is the increase in death rates. According to WHO, the neonatal mortality rates have reached 10.31 , the infant mortality rates have reached 16.65, and the under-five mortality rate has reached 19.46 per 1000 live births.

Economic Negative Effects

If a disease isn't countered until the stage of a pandemic, it can result in long quarantines. Quarantines have extremely negative effects on the economy due to the inactivity of schools, businesses, and other related facilities. A great example of this is the outbreak of Covid-19, which had catastrophic effects on tourism in Egypt. There is currently no exact information available on the economic losses suffered by Egypt's tourism industry, because the Covid-19 pandemic's scope and consequences are unprecedented in the history of tourism. At this time, it is impossible to examine the pandemic's effects on supply and demand using conventional economic analytic techniques. However, as shown in figure (2) the numbers of international tourists in Egypt have immensely declined from around 13 million in 2019 to 3.7 million in 2020.

Figure 2: the numbers of international tourists in Egypt

Lack of industrial and agricultural bases

Although Egypt began industrialization many years ago (the 1920s), it is still far behind other countries that began the process much later than Egypt. The resulting problem is that the Egyptian manufacturing sector is losing ground in terms of trade, as the Egyptian economy faces competitive pressures from three directions: First, countries in the MENA region, such as Tunisia and Morocco, opened their economies early and took proactive measures to boost their competitiveness. Second, East Asian, and European transition economies are distinguished by more efficient productive structures that employ skilled labour and capital-intensive activities to produce higher value-added and higher-quality goods. Third, largely unskilled, labour-rich, low-wage economies such as China, India, and Bangladesh have been rapidly integrating into the global economy, putting increasing competitiveness pressures on countries exporting low-skilled manufactured goods such as Egypt. The constraints to having a thriving industrial sector are related to inefficient human resource development, technical constraints, legislative constraints, and economic constraints, according to this paper. As a result, the paper recommends increasing investments in human development, strengthening the capabilities of the public sector, improving small industries, and managing the process of integration into the global economy. The Egyptian government pays close attention to and supports young investors and entrepreneurs through a variety of programs, the most prominent of which is the Social Fund for Development. 170 thousand entrepreneurs are working on micro and small projects throughout Egypt, with total finance of 685 million LE based on a revolving fund.

Causes:

Illiteracy

Illiteracy is a big problem that faces Egypt. T
Egypt, especially among women. Illiteracy i
the causes is poverty and another one is the l
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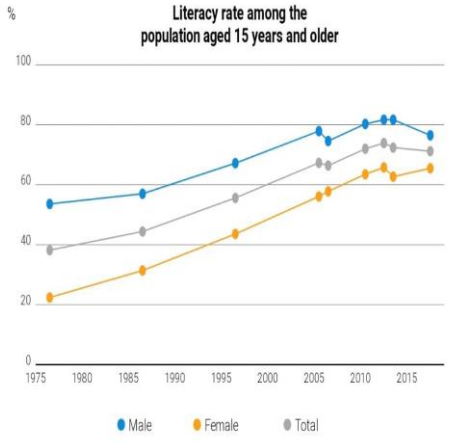
money to make that dream come true. For pe
their children join a school because he wants
they could not do, and the following (graph
illiteracy in Egypt whether male or female.



Graph 1.3 Literacy rate among population aged 15 years and older

Demographic Influences

Egypt faces a demographic problem as the distribution of people across the country is not stable and the place of urban congestion is far from most of the industrial resources even though industries are mostly around places of urban. As shown in (figure 3) the industrial bases in Egypt are only in the big cities.

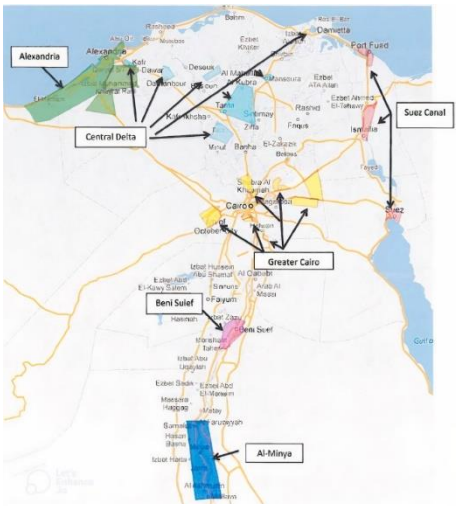


Figure 3 Egypt's industrial bases

Desertification

Desertification is the degradation of land in arid, semi-arid, and dry sub-humid areas known as drylands due to a variety of factors including human activity and climatic variations. Desertification makes many lands, even if they have materials for industry, difficult to use because it will be much more expensive. Egypt has a large area of arid areas (as shown in figure 4) that may contain some industrial material but cannot be used because it is not economically viable.

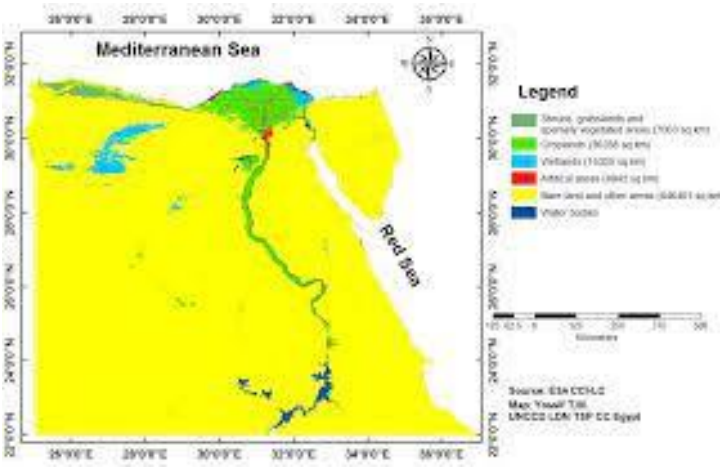


Figure 4 Desertification in Egypt

Desertification is the degradation of land in arid, semi-arid, and dry sub-humid areas known as drylands due to a variety of factors including human activity and climatic variations. Desertification makes many lands, even if they have materials for industry, difficult to use because it will be much more expensive. Egypt has a large area of arid areas (as shown in figure 1.5) that may contain some industrial material but cannot be used because it is not economically viable.

Using outdated technologies

Most industries continue to rely on outdated technologies to manufacture products that generate massive amounts of waste. Costs and expenditures for

old technologies are high. As a result, countries seeking to import goods avoid Egypt's products in favor of those produced in other countries that produce higher quality at a lower cost. Many businesses continue to manufacture high-end products using traditional technologies.

Lack of access to finance

Since the 1980s, the majority of Egypt's private sector has been comprised of formal and informal micro, small, and medium-sized enterprises. Although the size, location, and operations of these various businesses vary, they all contribute significantly to the value-added and provide accessible goods and services to the poor and middle classes... According to estimates, Egyptian SMEs employed approximately 2.2 million workers in 1998 and 8.3 million by 2004. According to the UNDP Egypt Human Development Report for 2008, SMEs account for approximately 90% of private enterprises, with most of them falling into the micro category. SMEs account for 80% of total value added from private-sector operations, and their employment share accounts for 66% of the total workforce and 75% of total nonagricultural manpower.

Impacts:

Unemployment

Unemployment refers to the proportion of the labour force that is unemployed but available for and seeking work. The unplanned planned industrial growth led to the closing of some companies and factories in Egypt and that caused unemployment. The rate of income is increasing every year. So, a good plan for industrial growth should flow. As shown in (Figure 5), Egypt’s unemployment rate has been rising during the last few years.

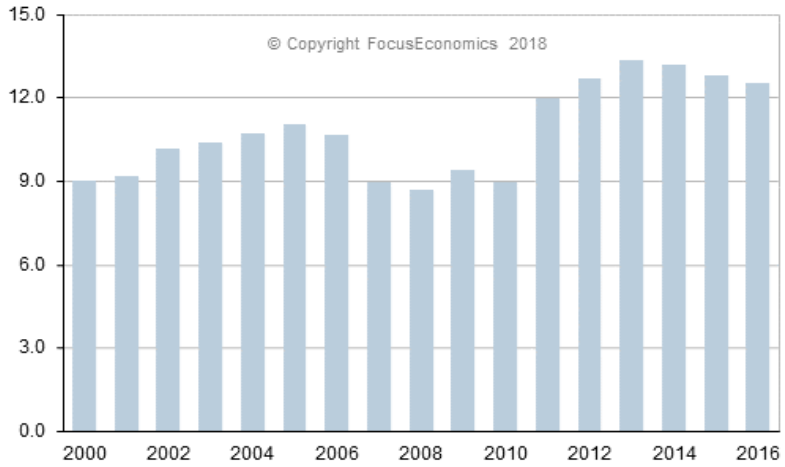


Figure 5 Unemployment rate in Egypt

Current Inflation

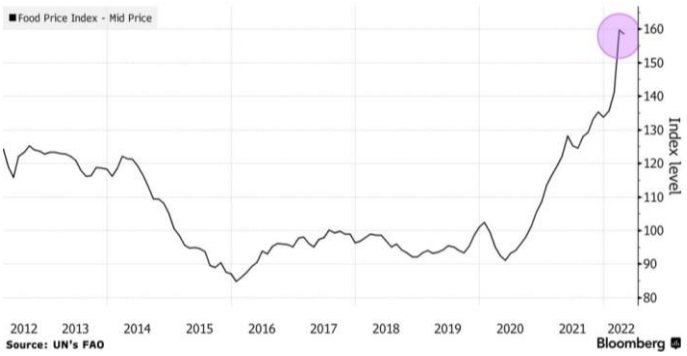


Figure 6 Food prices rates in Egypt

Because the current inflationary wave was caused by high commodity prices and supply shortages, raising Egypt's interest rates, which are already among the highest in the world, to limit demand will not solve the problem and may instead lead to stagflation due to price increases accompanied by a decline in purchasing power. The main cause that the Egyptian pound is continuous decreasing is that Egypt highly relies on importation from other countries by their currency. It causes the pound to decrease, and it cannot rise again as there are no big industries in Egypt that other countries can import from. As an impact of the inflation in the Egyptian current, it caused the prices of food to rise as shown in (Figure 6) in a way that never happened before.

Overcrowding of cities

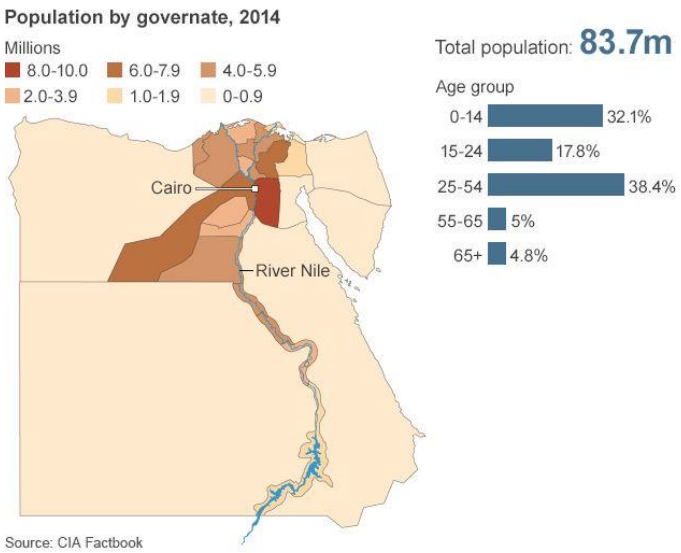


Figure 7 Egypt's distribution of population

Egypt's population crisis is exacerbated by the country's harsh geography: 95 percent of the population lives on about 4% of the land, a green belt roughly the size of Ireland that follows the Nile as it snakes through the desert and then fans out into the lush Nile Delta. According to official population estimates released by the Central Agency for Public Mobilization and Statistics, Egypt will have a population of more than 190 million citizens in 2052 if population growth continues at its current rate. Most of the people living in Egypt live in industrial cities as an impact of the misdistribution of industry in Egypt. As shown in (figure 7), most of the Egyptian population is concentrated in the big cities leaving upper Egypt and the two deserts of Egypt.

Improve the industrial and agricultural base

Egypt's land doesn't characterize by variety as shown in figure (8) shows that Nearly 96% of Egypt's area is desert and the lack of forests and meadows, the agricultural areas in Egypt don't exceed three percent, however, the labor force that works in agriculture represents one over four of the labor forces of Egypt and redound with eighth of the gross domestic product (GDP).

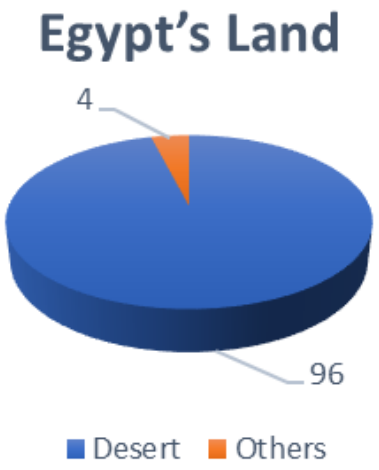


Figure 8: Egypt's land distribution.

The gross domestic product (GDP) in Egypt is $1,289,649,795,936 in 2020 as shown in figure (9). As shown in the graph, the percentage of agriculture in the GDP is very low, indicating the problem Egypt is facing.

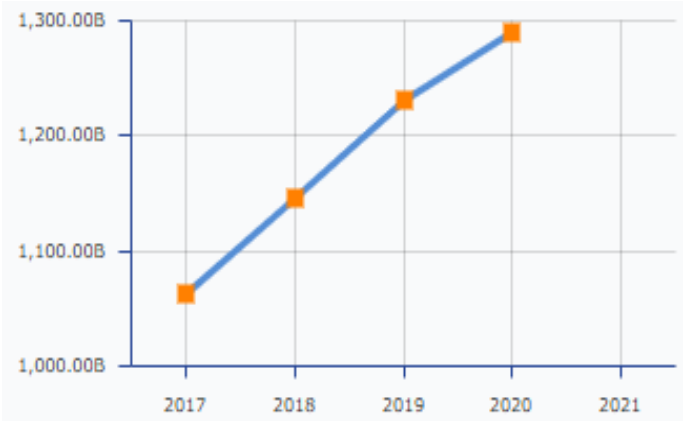


Figure 9: The gross domestic product (GDP) in Egypt

The growth rate of the GDP is 3.57%. This growth rate is relatively low and there are strategies the country is launching to develop its industrial and agricultural bases as the Egyptian Government's launch of the structural reform program in 2016 focused on raising the productive capacity and competitiveness of the real economy. It had a special focus on industry and agriculture.

The agricultural bases in Egypt are converged on the river Nile and the Delta and in upper Egypt which nearly forms 8.6 million feddan which represents only 3% of the total area of Egypt. According to USAID "Egypt's agriculture sector is dominated by small farms using traditional practices that do not meet international standards.". In order to improve the agriculture base in Egypt we have to cover the main components of sustainable agriculture which are soil management, crop management, water management, disease/pest management, and waste management.

The industrial bases in Egypt concentrate in Egypt in Badr, South Raswa in Port Said, Marghem in Alexandria, Al-Sadat City, Kafr Al-Dawwar, and Mahalla

Al-Kubra. The labor force that works in the industry is 1.5 million and the contribution of the industry is 32.01% of the total GDP. About 28.164% of employment in Egypt is in the industry which comes after services employment in Egypt according to (globaledge.msu.edu). In order to improve the industry, there are followed strategies such as making the case for cities as the main hubs of economic growth, Identifying the opportunities to unlock growth, considering how the national and global economies are evolving, map out the available levers and mechanisms, Find new ways of working and better-coordinating interventions, and Identify where cities lack the necessary policy tools and lobby for change.

Causes:

Rural-urban migration

Rural-urban migration in developing nations has its origins in the development of independent postcolonial nation-states following World War II, which made fast industrialization necessary for them to reach modernity through rapid industrialization. As a result, significant urbanization occurred in surrounding towns and cities where these enterprises were located. Along with this, the rising mechanization of agricultural labor led landless farmers from rural regions to migrate to cities in search of jobs in the industries. Rapid urbanization was consequently connected with increased rural-urban mobility in the majority of less developed nations. By increasing agricultural and industrial bases such a problem will be avoided according to “Datta, A. (2012). Migration and urban living in less developed countries”.

Desertification

Desertification causes a lack of agricultural bases. According to Stringer, desertification frequently brings with it “a reduction in vegetation cover, so more bare ground, a lack of water, and soil salinization in irrigated areas”. This can also result in a loss of biodiversity and noticeable scarring of the terrain due to erosion and the creation of gullies leading to losses in agricultural bases. Egypt’s land is relatively highly sensitive to desertification as shown in figure

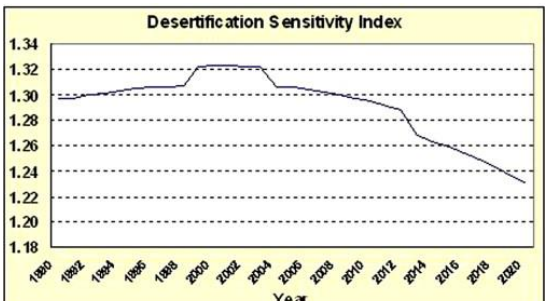


Figure 10: SDI in Egypt

(10); Sensitivity to desertification and drought is defined by a geometrical average of three soil quality, climate, and vegetation indexes.

Lack in the industry

The quantities of pesticides used in Egypt based on the Environmental Affairs agency, Egypt; January 2009, is about 600 tons/annually. These pesticides cause groundwater contamination resulted, by the leaching of nitrates and chemicals from them, and bacteria from livestock and feed wastes. Studies show that contaminated groundwater contains the highest concentrations of organochlorine and organophosphorus pesticides (Dahshan, Megahed, & Abd-El-Kader, 2016).

The economic problem

After researching the economic problem of Egypt, I got two probable explanations. One explanation for Egypt's economic downfall was a failure of leadership. Members of Egypt were forced to rely on a single export due to their reliance on agricultural production at the cost of other industries. As Egypt is building bridges and houses lavishly spending money borrowed from European banks. Another explanation for Egypt's economic problem was environmental. They didn't have the coal resources Britain and Europe had.

Impacts:

The Impact of Industrialization on Employment

It is important to evaluate the employment effect of various industries on the economy. This is because Egypt is a country that suffers from a high number of population and hence a high level of unemployment. Thus, the employment impact of the industry is an important angle in any economic research. Because Egypt is a labor-rich but capital-scarce country, the allocative efficiency of resources in manufacturing means that Egypt should focus on labor-intensive activities. Meaning that Egypt should specialize in textiles, wood and furniture, metal products, food processing, and paper, as in all these activities the value of the capital-labor ratio is below the mean value for the total manufacturing activities.

Lack of food resources

The lack of food resources in Egypt caused a necessity in importing food from other countries affected by the global crisis. For example, Egypt is suffering one of the biggest food crises in recent history, with the majority of its wheat supply cut off owing to the Ukraine conflict and Western sanctions on Russia. Last year, Russia and Ukraine accounted for 80 percent of wheat shipments in Egypt, the world's largest importer of wheat. This has had a severe impact on the country's subsidized bread program, which serves over 70 million people.

Lack of industrial bases

There is a lack of industrial bases. As a result, the unemployment rate is high in places where are no industrial bases, resulting in low-income, low-employment zones. The average unemployment rates are relativity high as shown in figure (11) according to the Central Agency for Packaging and Statistics in Egypt. Throughout the process of de-industrialization, People might get demotivated and discouraged when they perceive a lack of possibilities, which can lead to societal problems such as crime and mental health issues.

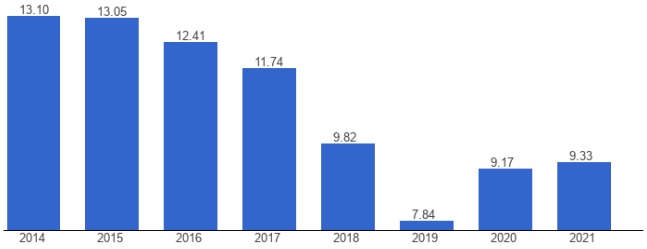


Figure 11: The employment rate in Egypt

Wages and finance

Wage levels have worsened, compared to cost, ranging between 35-40% in the private sector, and reaching between 92 and 107% in business sector companies, while global levels revolve to enable this industry to compete globally around 6 and 7% of the cost. Figure (12) shows the weekly wages in public businesses and the private sector, the graph is relatively steady even though inflation happening simultaneously.

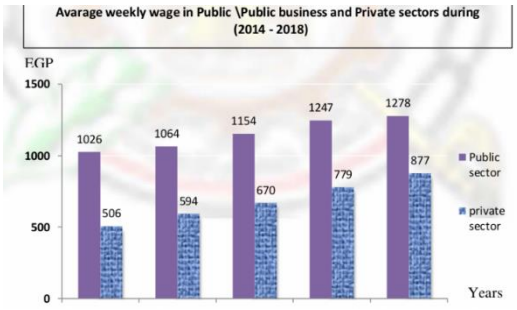


Figure 12: Weekly wages for public businesses and private sectors

Improving the scientific and technological environment in Egypt

There is no doubt that Egypt has long had a highly skilled research community, which currently numbers about 120,000 theoretical and applied scientists among 23 government institutions and 198 research centers. Based on the number of papers published in scholarly publications, there are positive indications. According to the SciMAGO SCOPUS database of country rankings, Egypt's production increased from 4,922 articles in 2006 to 10,295 in 2011, with substantial advances in agricultural sciences, engineering, computer science, medicine, and biochemistry, genetics, and molecular biology. In spite of that, innovation as a culture had practically vanished. Egypt was ranked 113th out of 142 nations in the Global Competitiveness Report 2011-2012 for the caliber of its scientific research institutions.

Nevertheless, Egypt's research institutions have recently undergone observable improvements. Egypt was ranked 105th in 2017 but moved up 10 spots to 95th in 2018 according to the International Innovation Index. Egypt's level of scientific and technological development, however, is still considerably below that of developed nations.

Causes:

Lack of money spent on Research and development

Research and development (R&D) is one of the most crucial factors that contribute to the advancement of science and technology. R&D develops existing and new core skills, advances existing and new technologies, and develops existing and new business processes through invention and innovation. One of the current problems existing in Egypt’s scientific environment is the lack of spending on R&D. Table (1) shows the amount of money spent on R&D by Egypt as a percentage of the GDP. Ranging only from 0.21 % in 2009 to 0.4

Table (1) The amount of money spent on R&D as a percentage of GDP

Year	Percentage	Annual change
2004/2005	0.24	-0.03
2005/2006	0.26	0.02
2006/2007	0.26	0.0
2007/2008	0.27	0.01
2008/2009	0.21	-0.06
2009/2010	0.24	0.03
2010/2011	0.40	0.16

% in 2011. According to the world bank, the percentage has increased to 0.96 % in 2020. Whi le this is a great improvement, it is still low in comparison with developed countries such as the United States with 3.45 %, Germany with 3.14 %, and even some Arab countries such as the UAE with 1.45 %.

The strain of the growing population on the educational system

Egypt's growing population puts a great burden on the country's education system. The overall number of children enrolled in elementary school increased from 9.5 million in 2005 to 12.2 million in 2017, while the secondary level increased from 6.7 million in 2009 to 8.9 million in 2015, resulting in increased funding requirements, capacity constraints, and overcrowded classrooms. In recent years, the pupil-to-teacher ratio has increased significantly in both primary and secondary school Consequently, it is estimated that 30% of kids lack basic reading and writing skills.

Furthermore, by most accounts, Egypt's higher education system is underfunded and ineffective. The World Economic Forum ranked Egypt's education system 130th out of 137 countries in its Global Competitiveness Report 2017-2018. This, combined with the lack of scientific institutions will have disastrous effects on the scientific and technological environment.

Impacts:

Declination of healthcare quality

To deal with varied conditions such as new diseases, the healthcare sector demands continuous innovation. As a result, a poor scientific and technological environment, and thus a lack of innovation, will harm healthcare and public health. Egypt's healthcare system is already encountering issues; as of February 2023, according to WHO, Egypt had reported over 24000 deaths due to COVID-19. The pandemic has shown a lack of adequate PPE supplies as well as a flawed public healthcare system. Therefore, improvements in the scientific and technological environment are crucial for the well-being of Egyptian citizens.

Negative effects on industry and economy

A solid scientific foundation is one of the most critical elements of a successful industrial system. From the early adoption of mechanical equipment to support

production processes to today's highly automated assembly lines, technological improvement has paralleled the industry's expansion. As a result, a lack of advancement in science and technology will cause Egypt to fall behind in terms of industry. Furthermore, the decline in the industrial sector would have a negative impact on other sectors such as agriculture and commerce.

Problem to be solved

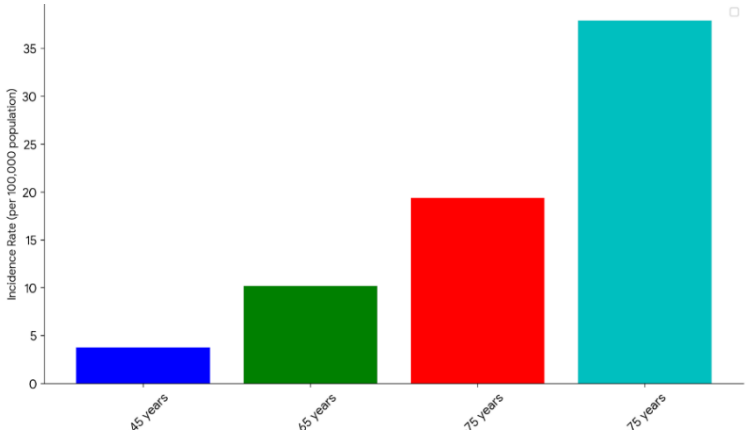


Figure 13 shows an approximate number for VTE patients in Egypt each year.

Venous thromboembolism (VTE), characterized by the formation of blood clots within the recesses of veins, emerges as a considerable health peril, frequently culminating in severe complications, such as pulmonary embolism, accumulation of blood clots in the lungs. Recent epidemiological data brings into sharp relief the significance of this health crisis, revealing a conspicuous and escalating prevalence of VTE on a global and local scale as well.

According to a study published in the Journal of Vascular Surgery, the estimated annual incidence of deep vein thrombosis (VTE) in Egypt is 12.1 per 100,000 population. This means that approximately 11,000 people in Egypt develop VTE each year. The study also found that the prevalence of VTE in Egypt is 0.2%, meaning that approximately 20,000 people in Egypt have VTE at any given time. Moreover, (Figure 13) shows the estimated annual incidence of deep vein thrombosis (VTE) in Egypt by age group. The incidence rate of VTE increases with age, with the highest incidence rate in the age group of over 75 years.

Positive consequences if solved

Economic Relief

The economic burden associated with the treatment of VTE and its complications would diminish. Fewer medical expenses related to hospitalizations, surgeries, and ongoing treatments would result in financial relief (Figure 14) for individuals and the healthcare system.

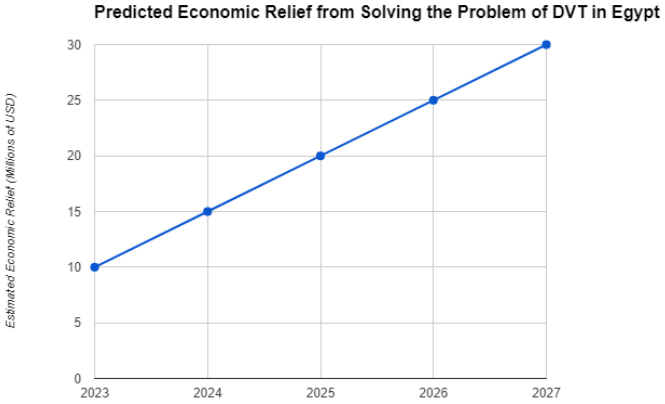


Figure 14 shows the financial relief from solving the problem

Enhanced Public Health

A decline in VTE cases would contribute to improved overall public health. Reduced instances of thrombosis-related complications, such as pulmonary embolism, would lead to fewer hospitalizations and a diminished burden on healthcare resources. Furthermore, as the incidence of VT Ediminishes, individuals would experience improved health and well-being. This could lead to increased workforce productivity as people are better able to engage in their daily activities and employment responsibilities.

Increased Public Awareness

People who are aware of the risk factors for VTE will be better equipped to identify them, take preventative action, and give priority to early intervention. Outreach programs and education campaigns could promote mentality by promoting consistent exercise, knowledge of the effects of lifestyle choices, and early medical consultation. An informed community is ultimately a valuable asset in maintaining the momentum created in the resolution of the VTE issue and advancing a culture of health-conscious decision-making and communal well-being.

Negative consequences if not solved

Increased Number of Deaths from Pulmonary Embolism (PE)

PE is a serious complication of VTE that occurs when a blood clot travels to the lungs and blocks blood flow. According to ScienceDirect data, the estimated annual number of deaths from PE in Egypt is 4.1 per 100,000 population. The highest death rate from PE is in the age group of over 75 years, with a death rate of 11.6 per 100,000 population (Figure 15).

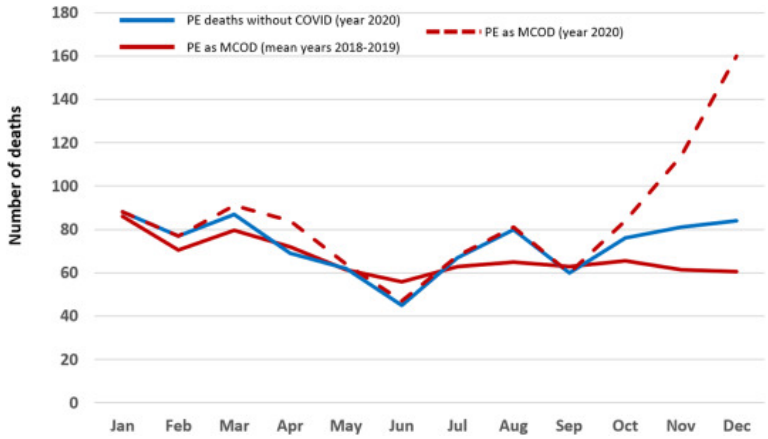


Figure 15 shows the number of Deaths due to PE in Egypt since 2018 till 2020.

Increased Healthcare Costs

The treatment of VTE and PE can be very expensive in low socio-economic countries. In Egypt, the estimated annual cost of treating VTE is $55 million, and the estimated annual cost of treating PE is $50 million. The cost varies with the age interval (Figure 16): the higher the age the higher the costs and expenses to maintain the safety of the patient health

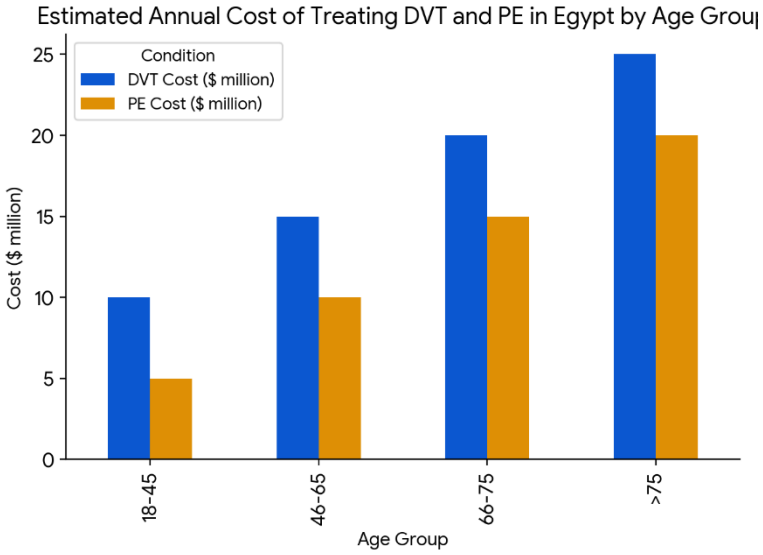


Figure 16 the variation of cost with age interval

Reduced Quality of Life

VTE can have a significant impact on quality of life. Patients with VTE may experience pain, swelling, and difficulty walking. Also, hypoxia (low oxygen

levels) is a prominent obstacle that causes an increase in blood viscosity and alterations in the endothelial lining of blood vessels. These changes may contribute to a pro-thrombotic state, potentially increasing the likelihood of clot formation.

Research

Topics related to the problem

Pulmonary embolism

Pulmonary embolism (PE) is the most serious complication of DVT. It is a blockage in the lungs caused by a piece of the clot breaking off and entering the bloodstream. Depending on the size of the clot, pulmonary embolism can be fatal because it may block blood flow to the lungs. In fact, 25% of PE patients suffer from sudden death, according to CDC.

The most common symptoms of Pulmonary embolism, shown in figure (17), include shortness of breath, fainting, and chest pain. Some patients may also suffer from rapid heartbeats, cyanosis, excessive sweating, and blood-streaked coughs. Pulmonary embolism can develop devastating health complications. The major complications caused by PE are Cardiac arrest, Cardiac arrhythmia, Pleural effusion, Pulmonary hypertension and infarction. PE can also develop into a chronic condition. According to CDC, 33% of patients with PE are likely to experience reoccurrences of the disease.

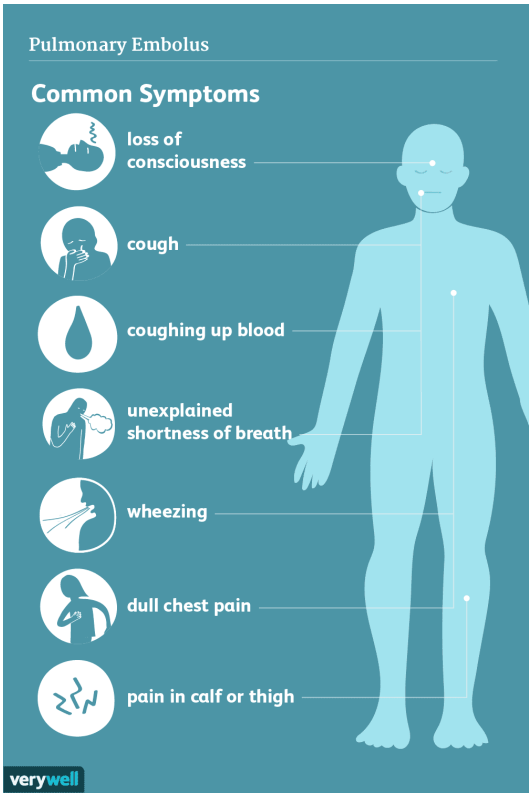


Figure (17) symptoms of pulmonary embolism

Chest X-ray is used to assess the lungs and heart. They display details regarding the dimensions, contours, and anatomical locations of the heart, lungs, bronchi (vast tubes that carry air), aorta, pulmonary arteries, and mediastinum (the region in the middle of the chest that divides the lungs). In addition, detailed images of the body's organs and structures can be created using magnetic resonance imaging, or MRI. A variety of other methods can be used in the diagnosis of PE. Examples include lab tests, V/Q scans, and Duplex ultrasound.

Post thrombotic syndrome

One of the significant long-term effects of deep vein thrombosis is the post-thrombotic syndrome (PTS), a painful and sometimes incapacitating condition. According to CDC, one-third to one-half of those who have had a DVT will also develop PTS. As a result of the clots formed due to DVT, blood pools in the patient's veins. This blood clotting results in symptoms like pain and swelling by increasing the pressure inside the veins. The medical term for the variety of symptoms that might result from injury to the vein is post-thrombotic syndrome. While some people only have minor symptoms, others have severe symptoms that significantly interfere with their day-to-day activities. Two of the main symptoms of PTS include claudication and paresthesia.

The term "claudication" describes muscle pain brought on by low oxygen levels. Among the symptoms are the following: Muscle soreness, ache, weariness, or pain whenever those muscles are utilized. ache in the feet, thighs, hips, buttocks, or calves. It is often caused by blood clots as they impair the blood's function of transferring oxygen all over the body. "Paresthesia" refers to the sensation of tingling, burning, pricking or prickling, skin-crawling, itching, and numbness on or just beneath your skin. It occurs spontaneously and without prior notice, affecting various parts of your body. Similar to claudication, paresthesia is caused by the lack of circulation, which affects nerves and prevents them from carrying signals to and from your brain. Other symptoms include cramps, tiredness and heaviness, and itching.

The symptoms of PTS can be relieved through what is known as “compression therapy”. The most often used type of compression therapy is the application of compression stockings. Patients follow the provider's directions and wear the stockings frequently, sometimes even every day. By improving blood flow in the veins and squeezing the calf muscles, the stockings reduce the severity of the symptoms.

Topics related to the solution

Machine learning

Machine learning is a subfield of artificial intelligence that is defined broadly as a machine's ability to mimic intelligent human behavior. It includes a variety of statistical techniques and algorithmic models to solve issues without the need for specialized programming. The majority of AI- and machine-learning-based algorithms are based on different approaches to learning. ML algorithms that

use supervised learning techniques include Decision Trees, Random Forests, Support Vector Machines, and Artificial Neural Networks.

Decision tree algorithms form a decision support tool that starts with a single node and determines the possible outcomes of that decision. The decision and its subsequent products are added to the tree until a final product is reached. Support vector machines, or SVMs for short, are classification algorithms that employ supervised learning to classify features in two group problems by dividing the data into segments using the largest margin hyperplane and organising the segments using the best fit. Artificial neural networks, or ANNs, are made up of an input layer, one or more hidden layers, and output layers. Each neuron in a layer is connected to every other neuron in the layer above and below through functional units.

Applications for machine learning are numerous and include face detection for security, improving productivity and lowering risk in public transportation, and, more recently, a number of applications in biotechnology and healthcare. Recent developments in this field have shown amazing growth and promise for relieving doctors of their workload while enhancing precision, forecasting, and care quality. The main contribution of recent machine learning developments in healthcare has been to support analysts' and doctors' roles in identifying healthcare trends and developing disease prediction models.

Well's Criteria

Wells' score, also known as Wells' criterion, is a scoring system used to determine the possibility of developing Venous thromboembolism. The Wells' score is based on several factors, each one assigned a certain number of points. The factors include the existence of active cancer, paralysis, recent immobilization or major surgery, large veins in the legs, pitting edema in one leg, swelling in the leg near a deep vein, and a history of DVT diagnosis. Each of the factors and their score are shown in Table (2). Doctors check patients for these factors and add the points assigned to the ones present. Through the total score, doctors can estimate the likelihood of having the disease, and thus, decide whether to continue with further diagnostic testing.

Table 2: the Factors of Wells' criterion

Symptom and risk factors	Points
Active cancer, or cancer that's been treated within last six months	1

Paralyzed leg	1
Recently bedridden for more than three days or had major surgery within last four weeks	1
Tenderness near a deep vein	1
Swollen leg	1
Swollen calf with diameter that’s more than 3 centimeters larger than the other calf’s	1
Pitting edema in one leg	1
Large veins in your legs that aren’t varicose veins	1
Previously diagnosed with DVT	1
Other diagnosis more likely	-2

The results of the wells’ criterion can be interpreted based on either a two-tier or a three-tier based model. For the two-tier model, if the score is 2 or higher, then DVT is likely. If the score is 1 or lower, then it is not likely. For the three-tier model, if the score is more than 3 then the development of DVT is likely. If it is 1 or 2, then the risk is moderate, and it is low if the score is 0 or less.

IoT and wearable medical devices

The phrase "Internet of Things" (IoT) describes how commonplace items and industrial machinery can be connected to a data network to facilitate the gathering and processing of data for the purpose of managing these items and developing new services. The IoT has evolved into specific vertical-market applications such as surveillance, security, transportation, food safety, and document management.

The advancement of IoT technology has sparked interest in a wide range of health practices aimed specifically at improving population health. A summary of the many IoT services and applications in healthcare has been provided by recent reviews. These services have been thoroughly described and have a wide range of applications in the management of single and cluster conditions. Some of these applications include the capacity for remote health care providers to track and monitor patients' progress in their health, enhance chronic condition self-management, aid in the early detection of abnormalities, speed up the identification and diagnosis of symptoms, provide early intervention, and boost medication adherence.

One of the most common forms of the implementation of IoT in the medical field are Wearable devices. "Wearable" refers to anything that a subject can wear without making daily tasks more difficult or limiting their movement. Wearability is a particularly important concept in domains such as fitness/sport, wellness, and healthcare monitoring. Wearable technology frequently uses traditional electronics that are powered by traditional batteries and can be either rigid or flexible. This covers accessories for mobile phones, such as gadgets, interfaces, and sensors. In other situations, wearable technology is more "disruptive," encompassing textiles and clothes with dispersed uses that closely integrate electronics.

Prior solutions

Olive oil processing plant "Leya" near El-Asamalia, Egypt

Chronic diseases are increasing in prevalence and mortality worldwide. Early diagnosis has therefore become an important research area to enhance patient survival rates. Several research studies have reported classification approaches for specific disease prediction. ANN with PSO is a project to predict five prevalent chronic diseases including breast cancer, diabetes, heart attack, hepatitis, and kidney disease. The project plays a role for early diagnosis of chronic diseases in hospitals, including through development of online diagnosis systems. The ANN prediction model constructed with a PSO based feature extraction approach outperforms other state-of-the-art classification approaches when evaluated with accuracy.

Mechanism:

1- **Date selection:** Datasets for five chronic diseases, including Breast Cancer, Diabetes, Heart, Hepatitis, and kidney disease, are collected from multiple online sources e.g., Kaggle, Dataworld, Github & UCI machine learning repository. Each dataset has information about numerous patients with various diseases; therefore, dataset features and instances vary.

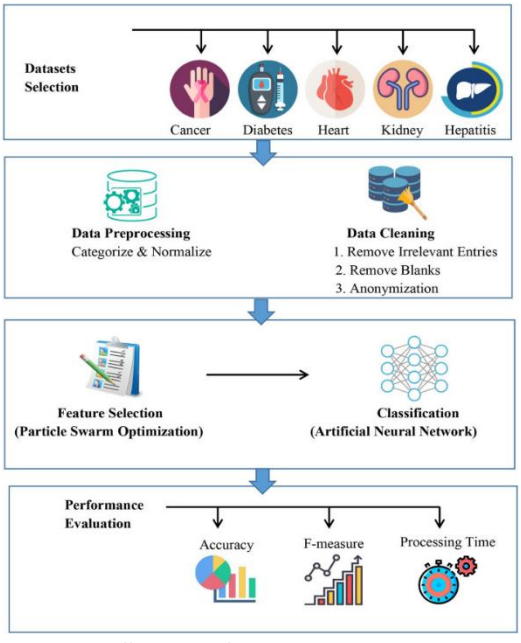


Figure 18 Illustrates the Date Pre-Processing steps

2- **Data Pre-processing:** To make the artificial intelligence algorithm more productive, pre-processing is essential before using data for model training. Data pre-processing steps (Figure 18) involve data extraction, anonymization, integration, cleaning, outlier detection, and duplicate removal. Therefore, all the datasets are pre-processed before using data for prediction.

3- **Feature Selection:** The main functionality of feature selection techniques is used to analyze that how each attribute takes part in output prediction. Feature selection is an essential approach to be used before model construction to reduce data complexity by eliminating irrelevant and useless features from data. Feature selection approaches reduce the data size so that the model takes less time in the training and testing phases. Feature selection is beneficial as it reduces the data size so that processing time, space, and power consumption are also reduced.

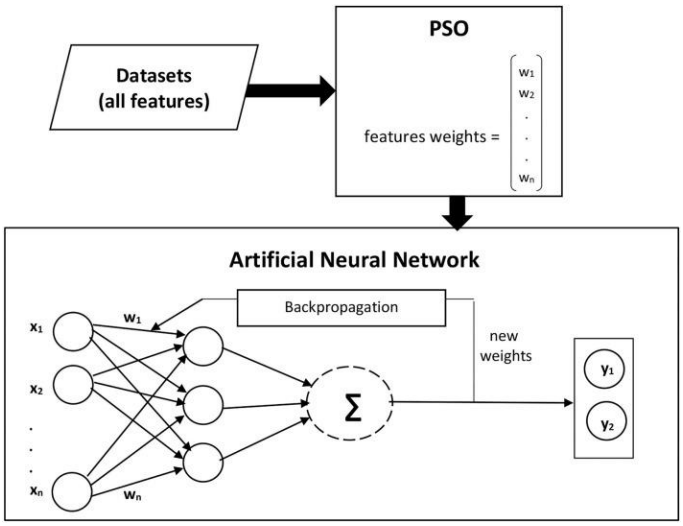


Figure 19 Artificial neural network Diagram

4- **Proposed Model Architecture**: The chronic disease detection model is constructed using advanced artificial intelligence algorithms, primarily artificial neural networks (ANN). The process involves supervised learning, specifically classification, with feature selection using Information Gain and Particle Swarm Optimization. The ANN is trained and validated through cross-validation, achieving optimal results with 200 training cycles. The model architecture (Figure 19), encompasses input features, assigned weights, and predicted outputs.

Points of strength

1. High accuracy

The information gain increased the performance of ANN and achieved the highest accuracy of 93.67%. Finally, PSO is applied and a 5% increase in accuracy is observed, presenting an accuracy of 98.67% (Figure 20)

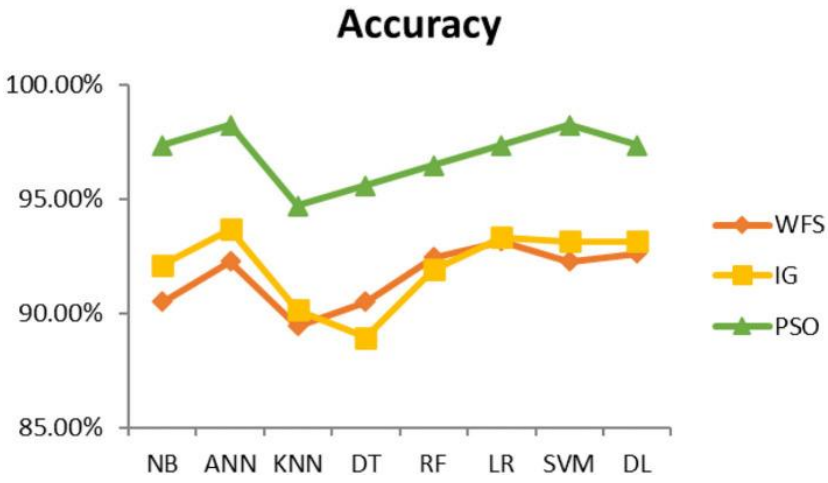


Figure 20 shows the accuracy for the ANN with PSO

2. Increase independence of patients

The project assisted individuals in diagnosing any of the lately mentioned diseases, offering them with a more self-governing experience by enabling them to obtain accurate results by inquiring about their age, gender, drug addiction, body mass index (BMI), blood pressure (BP), hypertension, lifestyle, and diet.

Points of weakness

1. Overlook social variables

Social, economic and historical factors can play into appropriate recommendations for particular patients. For instance, this AI system may be able to allocate a patient to a particular care center based on a specific diagnosis. However, this system may not account for patient economic restrictions or other personalized preferences.

2. Accessibility and Affordability

The technology's initial cost and accessibility may be limiting factors particularly for people with low incomes or living in areas with little access to technology. Greater accessibility and affordability will need huge efforts.

3. Inaccuracies are still possible

The project depends heavily on diagnosis data available from millions of catalogued cases. In cases where little data exists on particular illnesses, demographics, or environmental factors, a misdiagnosis is entirely possible. When prescribing a medicine for a specific condition, this factor becomes important. Remarking on this data gap, Yang, the project manager, says, “No matter the system, there is always some portion of missing data.”

4. Lack or user-Friendliness

The potential complexity and lack of user-friendliness in this AI-based project is another flaw. People with illnesses may find it difficult to use technology efficiently if the interfaces and interactions are not intuitively designed, which would lessen its impact. Prioritizing a more user-centric design and taking into account the varied demands and abilities of users in order to promote wider acceptance by costumers and practicality is crucial.

MyoExo

Figure 21 shows the ultra-sensitive resilient strain sensor that can be embedded in textiles and soft robotic systems.

Importantly, detecting and monitoring these neurological disorders remains a major obstacle to early diagnosis, patient care, and the development of better therapies. Since muscle symptoms can vary dramatically between patients with one disorder and overlap between disorders, the development of standard tests has been challenging. The diagnosis of these various disorders is often subjective and a trial and error approach of seeing how patients respond to various drugs is often required. In fact, up to 42% of patients with PD were reported to have been misdiagnosed early in their disease, and misdiagnosis rates are even higher (37 to 50%) for patients with essential tremor. In addition, many of these diseases are progressive and medication dose and timing needs to be adjusted and optimized over time, and ways to remotely assess medication effectiveness is needed for existing drugs, and also important for studying effectiveness of new ones.

Members of the Harvard Biodesign and Microrobotics labs, led by Wyss Associate Faculty members Conor Walsh and Robert Wood, are developing the MyoExo system with integrated novel wearable strain sensor technology to accurately detect and monitor muscle rigidity in PD patients, shown in figure (21).

Mechanism:

1- The “muscle-centric” soft wearable system is worn by a patient all day. Placed on muscles of persons with PD in the trial, the MyoExo sensors robustly registeres subtle changes in the curvature of muscles that occur when muscles become rigid.
2- The sensors found in the system can detect distinct physiological patterns in the patient’s muscles multiple times throughout the day, which can produce much more information about a patient’s condition than brief check-ups a few times a year.

3- The system allows healthcare providers to more effectively manage symptoms in neurological disorders and adjust treatment. It could also potentially help detect the disease much earlier and improve patients' quality of life by reducing the risk of falling.

Points of strength

1. **Accuracy in diagnosing**

This new approach could help to more accurately classify individuals with PD into those responsive to medication and those non-responsive, and could be an important step toward finding more personalized treatments. In addition, MyoExo sensors could help separate PD from other disorders, and accurately diagnose disorder-specific muscle dysfunctions.

2. **Accelerating patient diagnostics**

the Wyss Diagnostics Accelerator (DxA) is shortening the timeline required to develop urgently needed diagnostics from early-stage conception to clinical validation.

3. **Crossing the ultimate barrier to treating brain diseases:**

The ambiguous Brain Targeting Program (BTP) unites the freedom and creativity of academia with the drug development expertise and resources of industry. The BTP uses bioinspired engineering approaches to discover brain transport shuttles that dramatically improve delivery of drugs across the BBB.

Points of weakness

1. **High pricing**

The device isn't for the faint of heart or those who are on a tight budget. The cost of this wearable technology can range from a few hundred pounds to several thousand, depending on the features it provides.

2. **They can be difficult to operate**

Not only is there a chance that the device may be inaccurate, it can also be difficult to operate. This is often the case with devices that have a lot of features

crammed into a small space like MyoExo. It can take some time to learn how to use all of the different features.

3. **They can break easily**

Depending on where this wearable is worn, it is susceptible to being damaged or broken. Whether it's an active lifestyle or simple everyday wear and tear, the device can break easily, and often at the most inopportune time.

4. **They can be distracting**

One of the common complaints about this wearable technology is that it can be distracting. It can be very tempting in times when you’re supposed to be focusing on something else.

DeepMind's AI for Diabetic Retinopathy

According to the latest data from the Bureau of Disease Control and Prevention of the National Health and Family Planning Commission, China currently has 199.6 million diabetic patients and has become the world's largest country with diabetes. The primary-level ophthalmic screening service is one of the important tasks to improve primary-level medical services, and the corresponding ophthalmic imaging diagnosis technology is an important support for primary-level medical and health services. Therefore, it was very necessary to take the step to develop an AI subsidiary, developed a deep learning algorithm that can analyze retinal images with high accuracy to detect diabetic retinopathy, a leading cause of blindness.

Mechanism:

1- Neural Network Architecture: DeepMind's AI for Diabetic Retinopathy employs a sophisticated neural network comprising numerous interconnected nodes. Neurons within the network utilize a sigmoid-type transfer function, with linear functions potentially chosen for specific layers, especially for linear classification.

2- Layer-Specific Operations: The hidden layer processes information through the transfer function f, computing the output (O_j) based on the weighted sum of inputs ($\sum\omega_{ij}x_i$), adjusted by the threshold (q_j).
The output layer refines information with $O_k = f(\sum\omega_{jk}O_j - b_k)$, where b_k is the threshold of the output layer.
The transfer function, or stimulus function, utilizes a continuous sigmoid with a value range of (-1,1) or (0,1), reflecting the intensity and mode of interaction between node layers.

3- Error Calculation: The network gauges performance through error calculation, represented by $E = 1/2 \sum(T_k - O_k)^2$, comparing actual ($T_k$) and calculated ($O_k$) output values.

4- Self-Learning Mechanism: Critical to the network is the self-learning component, continually adjusting initial weights and error feedback between higher and lower nodes. The model is expressed as $\omega_{ij}(n+1) = h \times \phi_i \times O_k + \alpha \times \omega_{ij}(n)$, incorporating the learning factor (h), calculation error (ϕ_i), calculated output (O_k), and momentum factor

(α).

5- Mapping Capabilities: The BP neural network demonstrates versatile mapping capabilities, accommodating complex nonlinear functions, substantiated through mathematical proofs.

6- Validation Through Diagnosis: DeepMind's AI underwent rigorous validation, comparing diagnoses with specialists using fundus photos of 2,000 patients. The AI consistently achieved an accuracy of 95% or higher, establishing its readiness for practical application in diabetic retinopathy diagnosis.

7- Validation Through Diagnosis: DeepMind's AI underwent rigorous validation, comparing diagnoses with specialists using fundus photos of 2,000 patients.

BP neural network test results.

BP neural network	Diagnosed	Misdiagnosed	Accuracy (%)
Training result	116	4	96.67
Test result	77	3	96.25

Figure 22 shows the accuracy for the model.

Points of strength

1. **High Accuracy**

   the DeepMind model has high accuracy in detecting and diagnosing patients with diabetes with an accuracy of 96.25%. (Fig.22)

2. **Increased accessibility**

   AI screening can be implemented in primary care settings, expanding access to DR detection for patients who might not otherwise have access to specialist care.

3. **Cost-effectiveness**

   AI screening is potentially more cost-effective than traditional methods, as it can identify patients with DR who require further evaluation while reducing unnecessary referrals.

4. **Standardized assessments**

   AI algorithms can provide consistent and objective assessments, reducing potential bias and variability in diagnosis.

Points of weakness.

1. **Limited data availability**

AI models require large amounts of high-quality data for training, which may not be readily available in all settings.

2. **Accuracy limitations**

While AI models are constantly improving, they can still make mistakes, leading to false positives and negatives.

3. **Over-reliance on technology**

Overdependence on AI technology can lead to issues with system maintenance, data security, and potential bias in algorithms.

4. **Ethical concerns**

The use of AI in healthcare raises ethical issues related to data privacy, transparency, and potential bias in algorithms.

5. **Integration with existing healthcare systems**

Integrating AI screening systems into existing healthcare workflows can be challenging and require adjustments to infrastructure and protocols.

Chapter II

Generating & Defending a Solution

Solution requirements

Efficiency:

The solution must be efficient to achieve the best results possible. Efficiency is crucial for any project especially in the medical field; efficiency insures that the project has the desired effect in the patients and contributes positively to the public health sector.

Ease of implementation:

For the solution to be classified as a successful one, it is essential for it be easily implemented in the medical field. Ease of implementation in the medical field would help make it accessible for all patients and would give it a wider range of effect.

Practicality:

Practicality is one of the most important factors that must be considered for the project to be successful. It ensures that the project is easy to use for anyone, which helps patients be more independent and decreases the frequency of their hospital trips. All of this would help improve the quality of life for patients.

Design requirements

Accuracy:

When assessing classification problems, the most well-known machine learning model validation technique is accuracy. It is a simple model to both understand and implement. In machine learning, an accuracy score is an assessment metric that calculates a model's proportion of accurate predictions to total predictions. The computation involves dividing the total number of predictions by the number of correct predictions. The chosen accuracy threshold for this project is 80%.

Sensitivity and specificity:

The ability of a machine learning model to identify positive instances is measured by its sensitivity. It is sometimes referred to as recall or the true positive rate (TPR). Put differently, sensitivity quantifies the percentage of true positives that are accurately recognized as such (that is, the proportion of ill individuals that are correctly recognized as having the illness). Sensitivity or true positive rate can be computed mathematically as follows:

Sensitivity = (True Positive)/(True Positive + False Negative)

The percentage of true negatives that the model correctly identifies is known as specificity. A high specificity indicates that the model is correctly classifying the majority of the negative results, whereas a low specificity indicates that many negative results are being incorrectly labeled as positive. Therefore, the specificity in this instance can be characterized as a measurement of the percentage of individuals who are not afflicted with the illness that were accurately identified as such by the prediction. Specificity can be computed mathematically as follows:

Specificity = (True Negative)/(True Negative + False Positive)

The chosen threshold for both sensitivity and specificity is 80%.

Selection of Solution

The project was chosen to best achieve the design requirements, obtaining the highest accuracy among all the diagnostic tests for the Pulmonary Embolism. Each circuit component in the project was chosen to do a specific function. These components are:

Max30100 oximeter

The MAX30100 is made up of two high-intensity LEDs (RED and IR, both of which have different wavelengths) and a photodetector. measures the amount of reflected light using a photodetector after shining both lights onto the finger or wherever the skin isn't too thick and both lights can easily penetrate the tissue. So, the higher the hemoglobin content of the blood, the redder the blood and the more IR light is absorbed.

Ds18b20

The sensor is composed of a basic silicon diode. In a diode, the bandgap voltage at different current densities is proportional to the diode's temperature, providing a proper reading for the temperature.

Random Forest model

Random Forest is a classification machine learning model. The purpose of the model is to divide the data into two or more groups. Random Forest uses ensemble classification, which is a type of classification that utilize numerous

classifiers to improve the performance of the model. Using the ensemble classification, the ensemble model provides a higher quality amongst all the AI-models.

Selection of Prototype

The prototype was decided to be a smart system that can help VTE patients. It will give the patients access to self-prediction of PE complications in home or hospital. Using fast responding sensors, the prototype will be able to make the PE prediction and provide real-time mentoring for the heart rate, oxygen saturation, and temperature. The prototype system, as shown in figure (23), is made up of three parts: machine learning model, mobile application, and circuit.

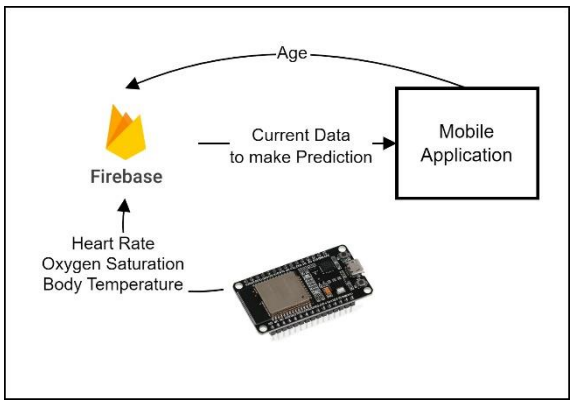


Figure (23): diagram for the prototype smart system

First, a machine learning model will be implemented using data from patients. Half of the data will be from patients who hadn't had complications after the data collection, while the other half will be from patients who had PE complications in the days after data collection. The machine learning model will use the parameters from the sensors to learn the patterns from the data and make prediction. After implementing the model, it will be converted to TensorFlow Lite, a file format that can be integrated in the mobile application.

Second, the circuit design contains a microcontroller with Wi-Fi module connected to a body temperature sensor, heart rate meter and oximeter. After the microcontroller read the three readings from the sensors it will use the Wi-Fi module to send them to a pre-made real-time database on Firebase.

The mobile application will have three main screens. The first screen is the user data where the patient will input the demographic data used in the model prediction: age. That data, then, will be stored to real-time Firebase database. The second screen will show the prediction results of the integrated machine learning model after retrieving the data from Firebase. The final screen will contain real time graphs of the data from the sensors: heart rate, oxygen saturation, and body temperature.

Chapter III

Constructing and Testing a Prototype

Materials & Methods

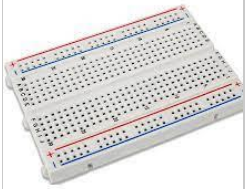
Material	Quantity	Description	Usage	Image	**Cost**	**Source of purchase**
Oxi-meter Sensor MAX30 0100	1 piece	Electronic sensor	Used to measure the oxygen concentration in the blood stream and heartbeats		80 L.E	Electronics store
Body Temper ature Sensor	1 piece	Electronic sensor	Used to measure the body temperature		55 L.E	Electronics store
Jumpers	30 pieces	Connectors	Used in the connection of bread board and the sensors		0.75 L.E each	Electyronics store
Bread Board	2 pieces	Electronic chip	Used as relay for the jumpers		50 L.E	Electronics store
Firebase		Application	Used in storing the patients' data to connect the application with the ESP32		____	_____

Table (3) Materials used in the prototype construction

Methods

1- The chosen parameters are heart rate, oxygen saturation in blood, temperature, and age.
2- A real-time Firebase database was created to store the data updates from the sensors, and the demographic data from the patients.
3- Figure (24) shows the flowchart of the communication between the application, Firebase, and ESP32.

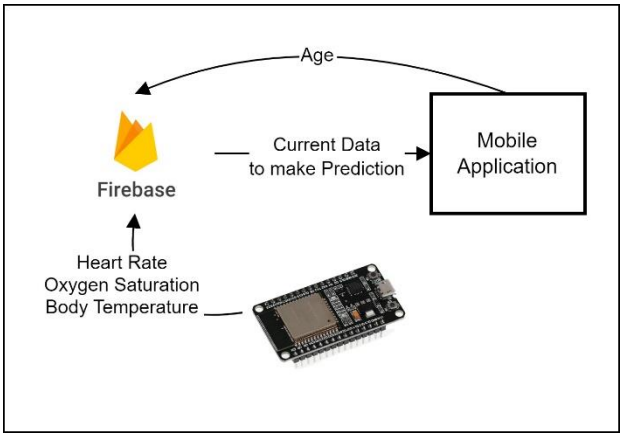


Figure (24) Communication flow chart

4- The design of the circuit figure (25) was created by combining the connections of the MAX30100 heart rate and oximeter sensor and DS18B20 temperature sensor.

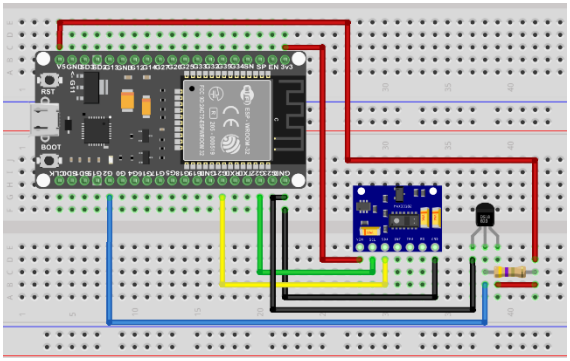


Figure (25) The circuit diagram

5- A dataset of 4000 cases containing the specified parameters as well as whether the corresponding cases developed complications of Pulmonary embolism was used.
6- KNN, Random Forest, ANN, and SVM machine learning models were implemented using Python to compare the performance of each model and use the model with highest accuracy.
7- Each model was trained on 80% of the data and testing them with the remaining 20%.
8- The model with highest accuracy was converted into TensorFlow Lite, which supports the implementation of mobile applications.
9- A mobile application was created using Flutter on Arduino Studio, allowing the patients to:
    a. Input their age and gender,
    b. View the output of the sensors,
    c. Get the results of the Random Forest model.

Safety precautions

1- Wearing protective equipment including lab coats and gloves, for safe contact with electrical components.

2- Carefully drying hands, protective equipment, and work area to ensure safety from electric components.

3- Taking the load limits of the electric components into consideration, to prevent the overloading of the electric components and their potential dangers.

4- Consulting professionals when dealing with electric components.

Test plan

The Ai model was tested with the remaining 20% of the cases for the accuracy, sensitivity, and specificity of the model.

The circuit and the application were tested to make sure of the responsiveness of the sensors, as follows:

a. The ESP32 was connected to a power source.
b. The axillary temperature was measured by the sensor.
c. The finger of the user was placed on the MAX30100 sensor to measure the heart rate and oxygen saturation.
d. The changes in the parameters along with the predictions were viewed on the application.

Design requirements

1- The Ai model must achieve an accuracy not less than 80%.
2- The Ai must achieve a specificity and sensitivity of at least 80%

Data Collection

Tools

1- **Max30100 Oximeter:** Used to measure the heart rate as well as the Oxygen concentration of the patient.
Accuracy: 97.14% for Heartrate and 99% for Oxygen concentration.
2- **Ds18b20 Temperature sensor:** Used to measure body temperature of patient.
Accuracy: (+/-)0.5 C

Results

Negative results

Prior to the Random Forest, other machine learning models were used. The models used include ANN, KNN, and SVM. However, those models achieved accuracies less than the specified design requirements, and thus, the Random Forest model was chosen as it achieved the required efficiency.

Positive results

The project satisfied all the specified requirements. First of all, the Ai model achieved an accuracy of 92.25%, correctly predicting 738 out of 800 cases. The confusion matrix for the Ai model is shown in figure (4). Second, the project achieved a specificity of 92.42% and a sensitivity of 92.02%. Figure (5) shows the performance graph of the model, comparing the accuracy, specificity, and sensitivity.

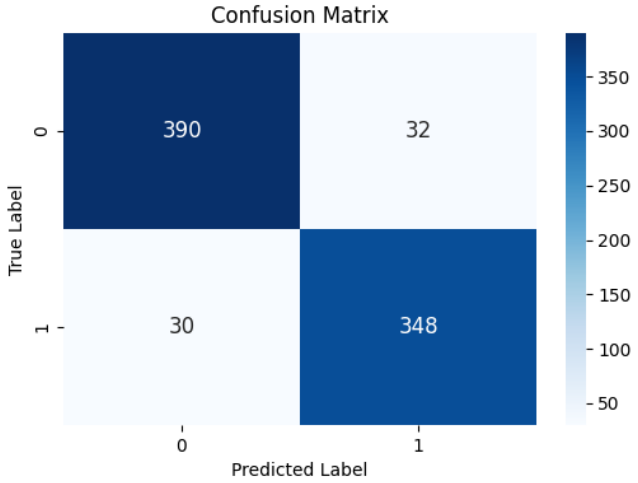


Figure (26) confusion matrix

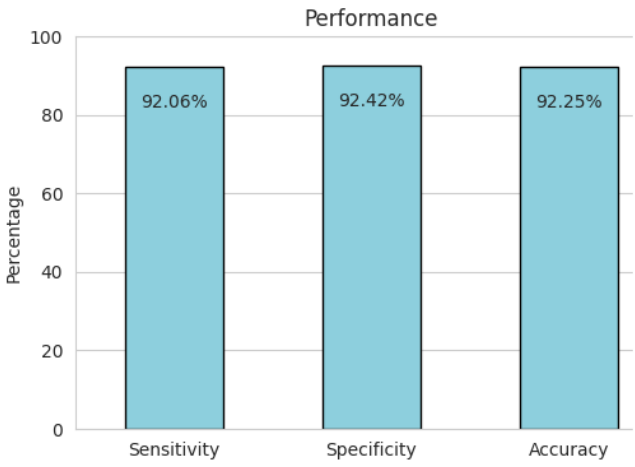


Figure (27) Performance graph

Chapter IV

Evaluation, Reflection, Recommendations

Analysis and Discussions

Venous clot formation in pulmonary embolism

Pulmonary Embolism (PE) describes a blood clot that blocks and stops blood flow to an artery in the lung. In most cases, the blood clot starts in a deep vein in the leg and travels to the lung. (Lavorini, 2013) The most common forms of PE occur in arteries and lead to myocardial infarction and stroke. Deep vein thrombosis mostly occurs in the legs and is associated with pulmonary embolism (PE), which is the formation of blood clots within the lungs, causing respiratory risk factors that may cause to death. (BI.3.01) A blood clot contains a mixture of platelets and fibrin and in some cases red blood cells. Venous clots form under low shear stress on the surface of a largely intact endothelium. (Mackman, 2012) They are fibrin-rich (so called "red clots" because they also contain red blood cells) and are treated with anticoagulant drugs.

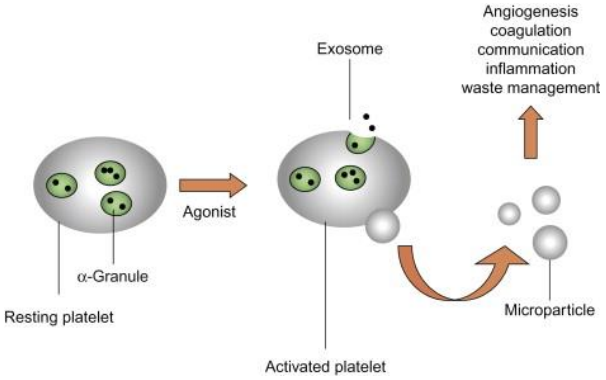


Figure (28) illustrates the Thrombocyte Release Reaction

The process begins with vasoconstriction, narrowing blood vessels to minimize blood loss. In response, platelets adhere to the exposed collagen at the injury site (BI.3.05). Adhered platelets release chemicals that make nearby platelets sticky. This initiates the platelet release reaction, attracting more platelets to the injury site, shown in figure (28).

The intrinsic and extrinsic pathways (Sanjeev Palta, 2014) converge at Factor X, triggering the coagulation cascade. This cascade involves a series of enzymatic reactions that ultimately convert prothrombin to thrombin.

Thrombin plays a central role by converting fibrinogen into fibrin threads. Fibrin threads form a mesh that traps blood cells, creating a stable blood clot.

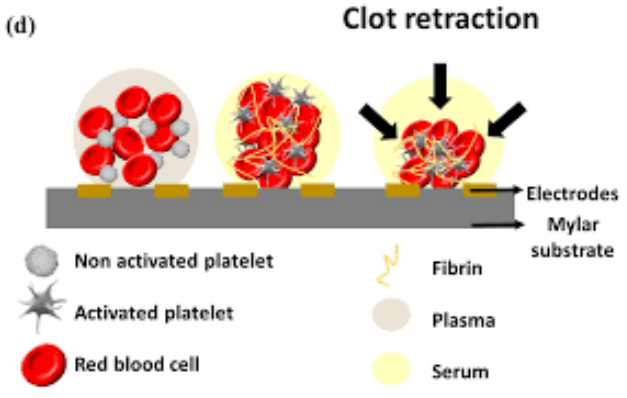


Figure (29) illustrates the clot retraction.

The clot contracts (BI.3.03), pulling torn areas together in a process known as clot retraction, forming the venous clots, shown in figure (29).

Thus, after the formation of venous clots along the whole body, the symptoms, swelling Pain, tenderness, redness of the skin, difficulty breathing, faster than normal or irregular heartbeat, chest pain or discomfort, which usually worsens with a deep breath or coughing, coughing up blood, very low blood pressure, lightheadedness, and fainting start to appear. Afterward, the DVT and PE complications begin until the patient's condition worsens.

System overview

As shown in the flow chart of the system in figure (24), there are two separate types of data inputted through the Ai model: health parameters – including heartrate, oxygen concentration, and temperature – and demographics – including age and gender. The health parameters are measured using the corresponding sensors, while demographics are entered through the mobile application. The data is then stored in a fire base until requested by the mobile application. In the application, patients can track their health parameters and check for the possibility of complications using the prediction feature. When a prediction is made, the data is requested by the application and is transmitted from the fire base. It is then analyzed by the Ai model implemented in the application to predict the risk for complications.

Circuit components and communication

Max30100 oximeter

The MAX30100 is made up of two high-intensity LEDs (RED and IR, both of which have different wavelengths) and a photodetector. These LEDs have wavelengths of 660 nm and 880 nm, respectively. The sensor uses a technique called a photoplethysmogram, which measures the amount of reflected light using a photodetector after shining both lights onto the finger or wherever the skin isn't too thick and both lights can easily penetrate the tissue.

The higher the hemoglobin content of the blood, the redder the blood and the more IR light is absorbed. The amount of reflected light varies as the blood is pumped through the finger with each heartbeat, causing a changing waveform at the photodetector's output and displaying the heartrate reading. Similarly, blood that has been deoxygenated absorbs more red light and more infrared light. The oxygen concentration in the blood is determined by calculating the photodetector's ratio of IR to RED light.

Ds18b20

A silicon band gap sensor, such as the ds18b20, is reliant on the proportional relationship between temperature and bandgap voltage. The sensor is composed of a basic silicon diode. In a diode, the bandgap voltage at different current densities is proportional to the diode's temperature. As a result, a distinct signal

is produced when the bandgap voltage varies due to changes in the diode's temperature.

ESP 32

As studied in Ph.03.04, certain components can be used to transfer data from a sender to a receiver. In this case, the circuit containing data about the heartrate, blood oxygen concentration, and temperature is the sender, while the application, containing the AI model, is the receiver. To achieve such task, the ESP32 development board was used as the microcontroller in the circuit. The ESP can accomplish the regular tasks of a microcontroller, but it also contains a Wi-Fi module, which is crucial for communication.

Through the use of a Wi-Fi module, devices can establish wireless network connections, access the internet, share files, and interact with other devices in the Wi-Fi network region. The connection of the wi-fi module to the mobile application is facilitated by a device known as the Access point, a device that links a wireless network to a wired network. It serves as a hub for the wireless network, enabling connections to the internet and inter-device communication for gadgets like laptops, cellphones, and tablets (Harahap et al., 2023). Figure (30) displays the function of the access point.

Figure (30) the connection of devices to the internet through the AP

Wi-fi can readily transmit data through radio waves. The data is stored in the microcontroller's memory in the form of a binary signal. The wi-fi module converts the binary signal to a radio wave. Through the AP, the waves are transmitted from the module to wi-fi chips in laptops or smartphones, where they are stored in the fire base along with the demographic data. For a prediction to be made, the data is requested from the fire base, and it is transmitted through wi-fi to the mobile application, where they are analyzed by the Ai model to make the prediction.

Random Forest model

Random Forest is a classification machine learning model. The main purpose of classification models is to divide the data into two or more groups (classes). Used by Random Forest, ensemble classification is a type of classification that utilize numerous classifiers to improve the performance of the model. After each classifier outputs its own results, the final result of a new record is made by getting the most common result of all single classifiers: a simple voting process. Figure (31) shows a diagram of the process of classification (Parmar et al., 2018). Each single classifier in the Random Forest is a Decision Tree. Decision Trees operate like flow charts, reaching a decision, classification result, after answering several binary tests (Kotsiantis, 2011).

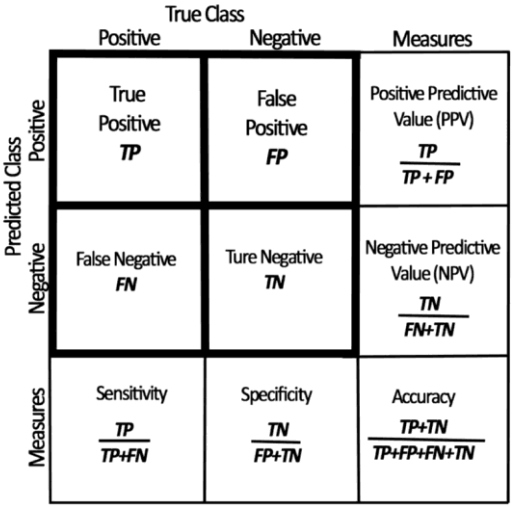


Figure (31) Confusion matrix, evaluation metrics equations

The Random Forest achieved the highest accuracy after compared with other machine learning models in paper by Wang it (Wang et al., 2019). In the training process, the decision trees are constructed using 80% of the data, while the remaining 20% is used in the recognition process to test the model performance. For the evaluation of the Random Forest model, 20% of the records was reserved to test the model. The model predicted if each record's patient will have complications. Those predictions, then, was compared to the real values to implement a confusion matrix (Ting, 2017). From the confusion matrix, the accuracy, sensitivity, and specificity can be calculated using equations shown in figure (10).

Conclusions

After a thorough study of the grand challenge of eradicating public health issues in Egypt, it was concluded that ICT can be used to facilitate the lives of venous thromboembolism patients. An Ai model was programmed with the intent of predicting complications of pulmonary embolism in patients. After running tests, it achieved the chosen design requirements for accuracy, sensitivity, and specificity, surpassing the 80% threshold, and proved its ability in precisely predicting complications of the disease. Comparing it with prior solutions, the project proved to pose a more efficient and sustainable solution. Therefore, it can be implemented in real life to combat the challenges in the public health sector as well as the industrial and technological one.

Recommendations

Educational Initiatives

Implementing and developing educational programs to increase awareness of people about DVT symptoms, risk factors, and the importance of early diagnosis. Also, creating informative materials, such as brochures, posters, and online resources, that includes how to use the project are crucial to disseminate information to the public. Moreover, launching targeted public awareness campaigns through various channels, including social media and community events to reach a wide audience.

Using TR250Z 25% Oxygen sensor

The TR250Z (shown in Figure 32) is a control board that provides multiple analog linear outputs of Atrations. It is designed to be rugged, maintenance-free and can be calibrated in any known oxygen concentration. The Fujikura 95% oxygen sensor used with the TR250Z is a zirconium based, current limiting sensor. This type of sensor has many advantages over other ways of measuring oxygen. For example, it does not require periodic calibration and will last at 3 or more years under normal conditions. Also, unlike common sensors, which has a maximum accuracy of 80%, this sensor has higher accuracy of 98.67%.

Figure (32) the TR250Z 25% sensor

Doppler Ultrasonic Velocity Sensor

A Doppler ultrasound, shown in figure 33, sensor emits high-frequency sound waves into the body, which bounce off moving blood cells. By analyzing the frequency shift in the echoed waves, the sensor detects blood flow velocity and direction. This non-invasive technique helps identify abnormalities, including potential blood clots, in deep veins like those affected by Pulmonary embolism (PE).

Figure (33) Doppler Sensor

Real-life application

The project's practical application entails developing a wearrable or portable medical device for continuous monitoring of people who are susceptible to Pulmonary Embolism (PE), such as patients recovering from surgery or people

with clotting disorders. With its temperature and oxygen concentration sensors, the device allows for continuous, non-invasive blood flow monitoring and provides real-time data. The application receives timely alerts from the system in the event that PE develops. The goal of this early detection and treatment strategy is to improve patient outcomes and care quality by reducing the likelihood of serious complications.

What would you tell another team who wanted to start where you stopped on your solution to help them?

Suppose a future team continues where the solution left off and tries to help facilitate the lives of PE patients. In that case, some improvements, recommendations, and suggestions will help significantly in the solution. Paying close attention to the used sensors and making sure they are of high accuracy and minimal error. In addition, the future team could try to find additional parameters to measure and train the Ai on them. Potential parameters include concentration and partial pressure of CO2, swelling, and breathing rate. Adding parameters would help increase the accuracy of the model, making it more suitable for use in the medical field.

How did working in this project help you and your team to become better STEM students?

Working on the Capstone pushed the team to improve. There are many aspects in which improvement has appeared. There are scientific, engineering, and social impacts. For the scientific impacts, working on the project allowed the team to improve the scientific writing, in which clearness, concision, and objectiveness are required. In addition, it allowed for a deeper comprehension of branches of science, since an integration between them was required when finding the solution and designing the prototype. As for the engineering impacts, working on the project provided an opportunity to apply the Engineering Design Process (EDP). It improved the team's planning skills since much planning was required when applying the EDP. For the social impacts, the project required teamwork and cooperation which improved the team's social skills as well as made them more accepting of differences of opinion. Communicating and sharing the results is also considered a social impact. These impacts together reflect how the team members have improved and gone forward as STEM School students.

Learning outcomes

Table 4 Learning outcomes used in the project

Ph.2.03	Direct Current Circuits	Helped in assembling the Arduino circuit for the automated system.
Ph.3.03	Light rays	Helped in understanding how light emitting diodes in the sensor were used to measure the heart rate and oxygen concentration.
Ph.3.04	Communication	The concepts learned in communication helped in gaining an understanding about how data is transferred to the mobile application
ENW.2.2.2	Writing academic English (Compose three paragraphs essay with an introduction, body, and conclusion with guidance and for self-initiated and assigned writing)	Helped in writing the abstract and the introduction in a clear way.
ENW.2.2.3	Writing academic English.	Used in writing in the portfolio and poster.
CS.2.05	Android Operating System	Helped in designing an Android app for the project.
CS.2.06	View Objects	Understanding it is important in creating a real-time monitoring system for the project. It can display current system conditions.
MA.2.10	Percentiles	used to assess the distribution of various parameters in the project, such as accuracy.
BI.3.01	Structure of clots	The understanding of blood clots structure helped us gain a better understanding of Deep vein thrombosis
BI.3.05	Vasoconstriction	The understanding of the process helped in understand more about the formation of clots.

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