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**Cairo University**

**• Faculty of Computers and Artificial Intelligence •**

**COV-19 Prediction Model**

**using machine learning algorithms**

***prepared by***

|  |  |  |
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**For my great colleagues,**

Thank you for your great work.

Contents

[***Chapter One: Introduction*** 4](#_Toc77981308)

[***1.1. Problem definition*** 4](#_Toc77981309)

[***1.2. Project Scoping*** 4](#_Toc77981310)

[***1.3. Project Objective*** 4](#_Toc77981311)

[***1.4. Project Methodologies*** 5](#_Toc77981312)

[***1.5. Solution statement*** 5](#_Toc77981313)

[***1.6. Software tools*** 5](#_Toc77981314)

[***1.7. Methodology*** 6](#_Toc77981315)

[***Chapter Two: Related Work*** 7](#_Toc77981316)

[***Chapter Three: System Analysis*** 9](#_Toc77981317)

[***2.1. Stakeholders and usage context*** 9](#_Toc77981318)

[***2.2. Product Vision*** 9](#_Toc77981319)

[***2.3. Product Backlog*** 10](#_Toc77981320)

[***2.4. Overall Architecture*** 10](#_Toc77981321)

[***2.5. Requirement source and validation*** 10](#_Toc77981322)

[***2.6. Functional Requirements*** 11](#_Toc77981323)

[***2.7. Non- Functional Requirement*** 11](#_Toc77981324)

[***2.8. Story Board*** 12](#_Toc77981325)

[***Chapter Four: Design*** 13](#_Toc77981326)

[***4.1. Use case diagram*** 13](#_Toc77981327)

[***4.2. Entity Relationship Diagram*** 13](#_Toc77981328)

[***4.3. Class Diagram*** 14](#_Toc77981329)

[***4.4. Sequence diagram*** 15](#_Toc77981330)

[***4.5. GUI Design*** 16](#_Toc77981331)

[***Chapter Five: Data Preparation*** 20](#_Toc77981332)

[***5.1. Objectives*** 20](#_Toc77981333)

[***5.2. Methods and analysis*** 20](#_Toc77981334)

[***5.3. Data Gathering*** 20](#_Toc77981335)

[***5.4. COV-19 statistics*** 20](#_Toc77981336)

[***5.5. Meteorological Data*** 20](#_Toc77981337)

[***5.6. Data Preprocessing:*** 21](#_Toc77981338)

[***5.7. Data scaling*** 23](#_Toc77981339)

[***Chapter Six: Algorithms*** 25](#_Toc77981340)

[***6.1. Auto Regressive Integrated Moving Average [ARIMA]*** 25](#_Toc77981341)

[***6.2. Long Short-Term Memory [LSTM]*** 28](#_Toc77981342)

[***6.3. Random Forest Regressor*** 30](#_Toc77981343)

[***6.4. Ada Boost Regressor*** 31](#_Toc77981344)

[***6.5. linear regression*** 31](#_Toc77981345)

[***6.6. Moving Average*** 32](#_Toc77981346)

[***6.7. k-Nearest Neighbors [KNN]*** 32](#_Toc77981347)

[***6.8. Naive Bayes [NB]*** 33](#_Toc77981348)

[***6.9. Susceptible infected recovered [SIR]*** 33](#_Toc77981349)

[***6.10. Resnet18*** 35](#_Toc77981350)

[***Reference*** 40](#_Toc77981351)

List of figures

[Figure 1: Agile lifecycle 6](#_Toc77981352)

[Figure 2: white mode design 17](#_Toc77981353)

[Figure 3: Dark mode design 19](#_Toc77981354)

[Figure 4: Egypt COV-19 confirmed cases stats vs Time 21](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981355)

[Figure 5: Egypt COV-19 confirmed cases stats vs Time 21](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981356)

[Figure 6: Egypt max temperature vs Time 22](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981357)

[Figure 7: confirmed cases and confirmed cases smoothed 23](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981358)

[Figure 8: Confirmed and is\_Increasing Indicator 24](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981359)

[Figure 9: non-stationary data 26](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981360)

[Figure 10: stationary data 26](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981361)

[Figure 11: actual cases vs prediction cases 26](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981362)

[Figure 12: Actual vs prediction cases 27](#_Toc77981363)

[Figure 13: conf Residual Plot 29](#_Toc77981364)

[Figure 14: fully connected nodes 35](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981365)

[Figure 15: convolution vs pooling layers 36](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981366)

[Figure 16: Resnet18 architecture 37](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981367)

[Figure 17 :Resnet18 architecture (flowchart) 38](#_Toc77981368)

**List of tables**

[Table 1: Related work 8](#_Toc77981369)

[Table 2: Stakeholders and usage 9](#_Toc77981370)

[Table 3: Product backlog 10](#_Toc77981371)

[Table 4: Requirements and validation 10](#_Toc77981372)

[Table 5: Non-functional requirements 11](#_Toc77981373)

[Table 6: Egypt COV-19 confirmed cases LSTM 28](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981374)

[Table 7: Egypt weather, is occasion indicator 28](file:///C:\Users\toqa%20khaled\Desktop\final%20document.docx#_Toc77981375)

[Table 8: Anova-1 table 29](#_Toc77981376)

[Table 9: Anova-2 table 30](#_Toc77981377)

# ***Chapter One: Introduction***

## ***1.1. Problem definition***

In our research project we aim to make a forecasting model to predict the status of the pandemic represented in number of new confirmed cases, new death, and new recovered cases, being able to reach such a reliable model, all interested parties can make group of decisions according to its domain, like governmental entities, medical sectors, etc. In this case, by each sector being ready to take the necessary important decisions based on its interest in advance, we will be able, in one way or another, to control the pandemic breakout prevent its spread uncontrollably.

## ***1.2. Project Scoping***

**1. The project will include the following:**

We expect that the model enables the intended users to perform the following functionalities: -

1. User can choose the preferred county to view its statical analysis.
2. User can view a graph representation of the predicted versus actual new confirmed cases for a pre-defined time frame.
3. . User can view a graph representation of the predicted versus actual new death cases for a pre-defined time frame.
4. User can view a graph representation of the predicted versus actual new recovered cases for a pre-defined time frame.

**2. The project will not include the following:**

Through our discussion with the different staff members and the competent authorities interested in the project, it became clear to us that there is a kind of misunderstanding regarding the tasks the project carries out, from these tasks that the project has the model to predict if the person could be regarded as effected with COV-19 or not.

## ***1.3. Project Objective***

introduce simple way to represent COV-19 analytical and predicted reliable statistical data. As we can get the intelligent predication model that enable us to get predicted reliable statistics with respect to training data by the help of historical data, we can then decide that this objective is successfully achieved.

## ***1.4. Project Methodologies***

Beginning of rapid analysis of the project and its conditions and functional requirement, it is better to choose one of the best iterative development methodologies that will enable us to easy respond to any types of changes. One of the most common changes that could be happened is the **requirement changes.**

The chosen software methodology is **Agile software development** which refers to software development methodologies centered round the idea of iterative development, The ultimate best value in Agile development is that it will enables us to deliver value faster and get small operating functionalities on hand and making feedback to these small functionalities

## ***1.5. Solution statement***

for solving this problem we made a website to help people know the future cases of covid to be careful if there is an increasing cases.

## ***1.6. Software tools***

|  |  |
| --- | --- |
| **Type** | **Technology** |
| Server-side Programming Language | Python 3.X |
| web framework | Django |
| Relational database management system | PostgreSQL |
| Markup language | Hypertext Markup Language. **[HTML V5]** |
| Style sheet language | Cascading Style Sheets. **[CSS Version 3]** |
| Style sheet framework | Bootstrap. **[ Version 4]** |
| Client-side Programming language | Java script |
| JavaScript library | jQuery. **[ Version 3.5.1]** |
| jQuery plug-in | DataTables. **[ Version 4.1.1]** |

## ***1.7. Methodology***

Beginning of rapid analysis of the project and its conditions and functional requirement, it is better to choose one of the best iterative development methodologies that will enable us to easy respond to any types of changes. One of the most common changes that could be happened is the **requirement changes.**

The chosen software methodology is **Agile software development** which refers to software development methodologies centered round the idea of iterative development, The ultimate best value in Agile development is that it will enables us to deliver value faster and get small operating functionalities on hand and making feedback to these small functionalities so we used Scrum to applicate agile methodology first we start with gathering requirements and we created user stories and the product backlog in this phase then we divided team roles to know who will be responsible for the scrum master role and product owner role, then we released planning so we prioritized user stories and estimate time for each one, then we create the sprints and through this phase, we did daily scrum meetings and sprint retrospective meetings at the end of each sprint, then draw burndown chart to know the actual time for each task is suitable for the time plan or not.

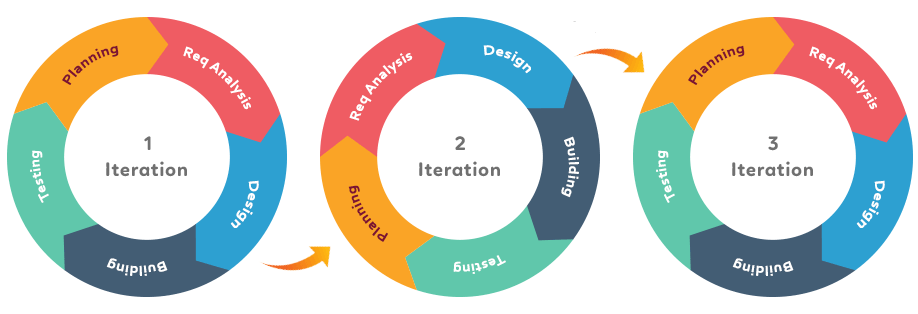


Figure : Agile lifecycle

# ***Chapter Two: Related Work***

|  |  |  |  |
| --- | --- | --- | --- |
| **Project Name** | **specification** | | **Solving** |
| **Coronosis** | Designs | Their design not usable, it is too crowded full of data and graphs, and some of it's not a tricky concept. | Our design more usable and efficient, Data and graphs are separated and easily accessible and informed. |
| Algorithm | We communicate with the owners of the site, and we discussed with them what data they were using, as if their answers were that they were not using factor (corona's influence factors), like the temperature of the state or any vacation, and so they were using algorithm not depending on the corona's influence factors. And their reference about data source when download them we found they use confirmed , death and recovery numbers from different source like Kaggle and WHO. | Our algorithm will depend on corona's influence factors and we trying to improve the accuracy of algorithm does not depend only on confirm, recovery and death numbers in worldwide. |
| **COVID19 India** | Data | They use India data only and not cover other countries , their data do not include corona's influence factors data like temperature and occasion. | Our site will cover all countries if the corona's influence factors data available for all countries. |
| Algorithm | they were using algorithm not depending on the corona's influence factors. And their API data we use it and we found they use confirmed , death and recovery numbers for India only. | Our algorithm will depend on corona's influence factors do not depend only on confirm, recovery and death numbers in worldwide. |
| Designs | Their graph not usable , not suitable to show cases number and not understandable. | Our graph more suitable to know the growth and attrition rate and easily accessible and informed. |
| **bobpagano** | Algorithm | We found their description and we found that they use SIR model When we looked for this model , we found that it was dependent on the probability and the average numbers, congestion and infections, and those probabilities were not entirely correct to predict, so the results were far from real. | Our algorithm does not depend on probability it depends on the corona's influence factors data and cases ,recover and death number. |
| Design | Their design does not include dashboard table only graph and that make more difficult for user to read number. | Our design includes dashboard and graph to make it easier for the user in all ways to know the information. |
| **IHME (COVID 19 Projections)** | Data | They collect the data from WHO that contain cumulative cases for all countries. | We collect data from different source WHO ,our world ,Kaggle and ECDC .etc. and that data contain cumulative cases , death and recovery not only cumulative daily cases , death recovery for all countries. |
| Algorithm | According to the data they use, it means that it is not dependent on corona factors and that they only apply algorithm to death number (they predict cumulative death numbers) for all countries. | We predict cumulative and daily for cases, recovery and death number. |
| Design | Their design does not include dashboard table only graph for cumulative death and that make more difficult for user to read number. | Our design includes dashboard and graph to make it easier for the user in all ways to know the information. |
| **auquan** | Algorithm | They publish their paper, we found that they use SEIR model after finishing their paper and search for that model we found it depend on probability and use constant number for predict like bed hospitals did not use any corona factors so not more accurate. | Our algorithm does not depend on probability it depends on the corona's influence factors data and cases, recover and death number. |
| Design | Their design does not include dashboard table only graph for cumulative death and that make more difficult for user to read number. | Our design includes dashboard and graph to make it easier for the user in all ways to know the information. |

Table 1: Related work

# ***Chapter Three: System Analysis***

## ***2.1. Stakeholders and usage context***

|  |  |
| --- | --- |
| **Stakeholder** | **Usage Context** |
| Governmental Entities | Based on COV-19 predications, different governmental entities can take decisions in advance related to county [imposing lockdown] |
| Medical Entities | Based on COV-19 prediction, medical sector can forecast the pandemic status with respect to people vaccination |
| Interested people | They have interest to know the futuristic situation about COV-19 |

Table 2: Stakeholders and usage

## ***2.2. Product Vision***

**Problem description**

As COVID-19 is a pandemic that has affected over 170 countries around the world. The number of infected and deceased patients has been increasing at an alarming rate in almost all the affected countries. Forecasting techniques can be better strategies and in taking productive decisions. Forecasting of a pandemic can be done based on various parameters such as the impact of environmental factors, incubation period of virous, the impact of quarantine, age, gender, and many more. Using COV-19 prediction model it will be possible to predict the number of new confirmed cases in addition to number of deceased and recovered patients, also our product provides additional feature represented as X-ray chest detection to decide whether the person is infected of not.

**System capabilities**

the new system should be capable of:

* Predict the number of infected patients
* Predict the number of deceased patients
* Predict the number of recovered patients
* Receive X-ray chest image and decide weather the patient is infected or not

**Business Benefits**

* For governmental and strategic management, giving predictive analytics about pandemic will constitute important factor for decision making process.
* Decide the proper conditions to impose the lockdown and to what extend will the lockdown imposed.
* Predict the consumers behavior and how changing in this behavior will affected the economy.
* Predict the economic status according to the pandemic status.

## ***2.3. Product Backlog***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **COV-19 PRODUCT BACKLOCK** | | | | | | |
| **ID** | **As a** | **I want to be able to** | **So that** | **Priority** | **sprint** | **status** |
| 1 | Manager | Know the expected rate of infected patient. | I will allow work from home | **HIGHT** | 1 | **IN PROGRESS** |
| 2 | Doctor | Know the expected rate of infected people | I can know the effect of the newly produced vaccine | **HIGHT** | 1 | **IN PROGRESS** |
| 3 | Minister | Know the expected rate of infected patient. | I will impose Partial/ complete lockdown | **HIGHT** | 1 | **IN PROGRESS** |
| 7 | Visitor | Know if my x-ray is regarded as infected with virous. | I will go to doctor or go on self-isolation | **HIGHT** | 1 | **IN PROGRESS** |

Table 3: Product backlog

## ***2.4. Overall Architecture***

As the project will be deployed over the public network server, and client computers will act as interfaces to allow a computer user to request services of the server and to display the results the server returns, the proposed architecture of project implementation is the **client-server architecture**.

## ***2.5. Requirement source and validation***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Requirement** | **Validity** | **Consistency** | **Completeness** | **Realism** | **Verifiability** |
| Forecast number of newly confirmed cases | Tick symbol | Tick symbol | Tick symbol | Tick symbol | Tick symbol |
| Forecast number of newly recovered cases | Tick symbol | Tick symbol | Tick symbol | Tick symbol | Tick symbol |
| Show the actual number of newly confirmed cases | Tick symbol | Tick symbol | Tick symbol | Tick symbol | Tick symbol |
| Show the actual number of newly recovered cases | Tick symbol | Tick symbol | Tick symbol | Tick symbol | Tick symbol |
| Show the actual number of newly deceased cases | Tick symbol | Tick symbol | Tick symbol | Tick symbol | Tick symbol |
| heck chest X-ray for infection | Tick symbol | Tick symbol | Tick symbol | Tick symbol | Tick symbol |

Table 4: Requirements and validation

## ***2.6. Functional Requirements***

* Predict the expected confirmed cases
* Predict the expected recovered cases
* Predict the expected deceased cases

## ***2.7. Non- Functional Requirement***

|  |  |
| --- | --- |
| **Non-Functional Requirement** | **Measurability and testability** |
| **Availability** | The percentage of system accessibility /availability could go over 95%, by deploying the system on a web-based cloud that has servers with enough capacity to handle and balance processing loads. |
| **Usability** | According to Nielsen Norman Group, to ensure the usability, system would be **learnable** by using proper user interface system design and good user experience, suggestions, and guides. By making the most relevant and important system functions at the first place and provide easy task flow to perform this function, system will ensure the **efficiency,** and to minimize **errors**, the textual data is rarely to be selected to information inputting techniques. |
| **Compatibility** | To ensure system compatibility, it would be hosted over cloud to enable any device with internet connection capability to reach the system. |

Table 5: Non-functional requirements

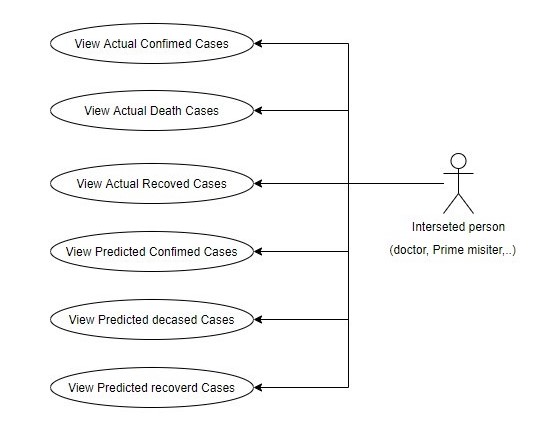
## ***2.8. Story Board***

Graphical user interface

Description automatically generated

# ***Chapter Four: Design***

## ***4.1. Use case diagram***



## ***4.2. Entity Relationship Diagram***

Diagram

Description automatically generated

## ***4.3. Class Diagram***

Diagram

Description automatically generated

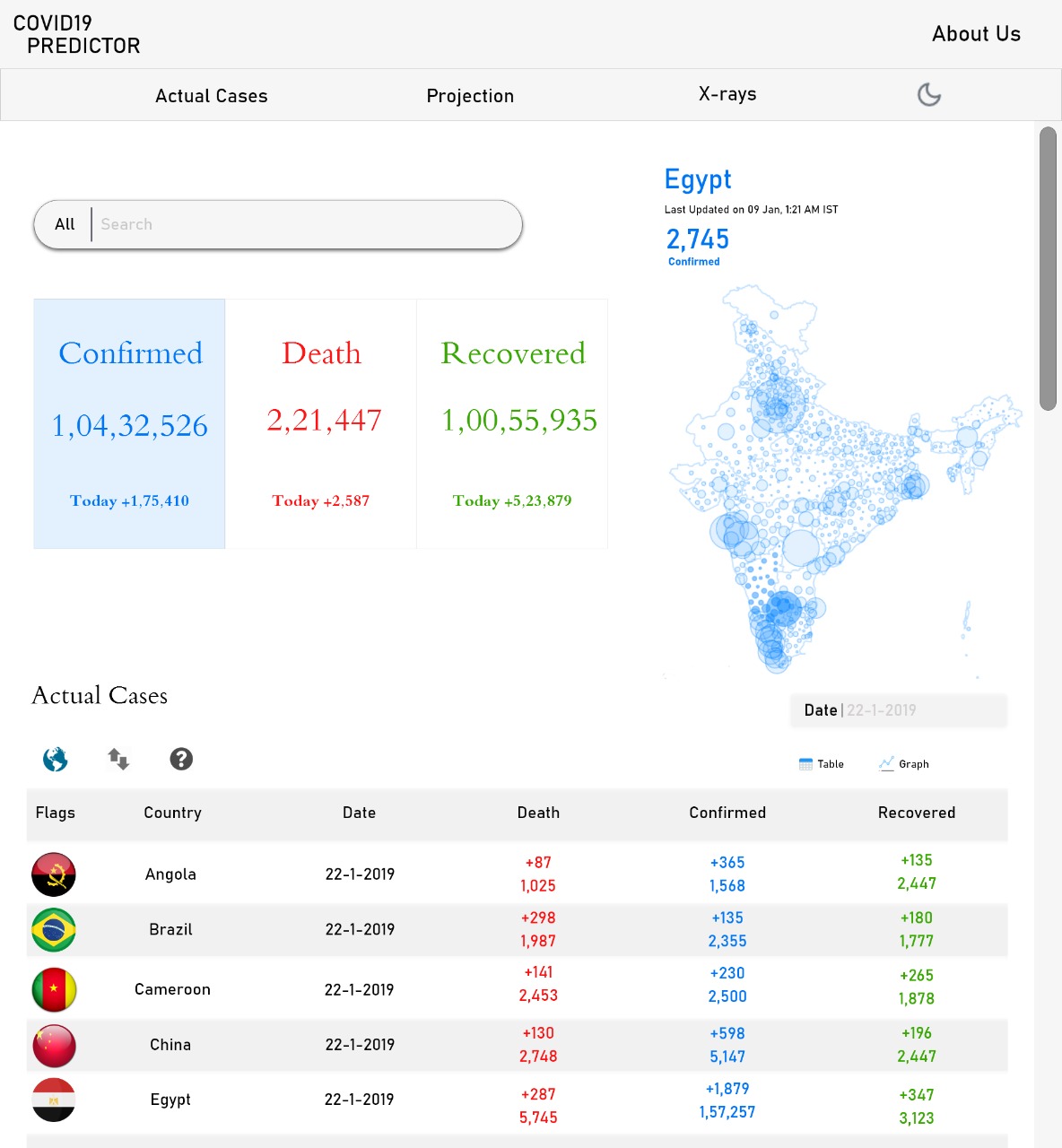
## ***4.4. Sequence diagram***

Chart, box and whisker chart

Description automatically generated

## ***4.5. GUI Design***

We have two modes white mode and dark mode

1. **Light** **mode**

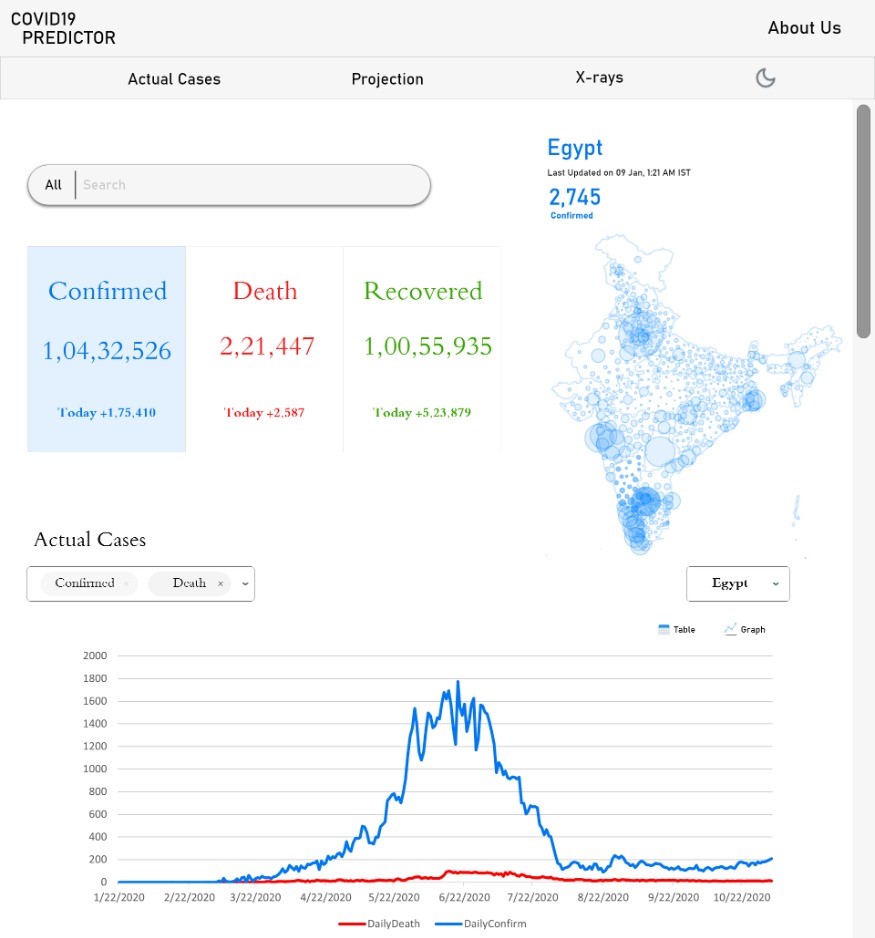


Figure 2: white mode design

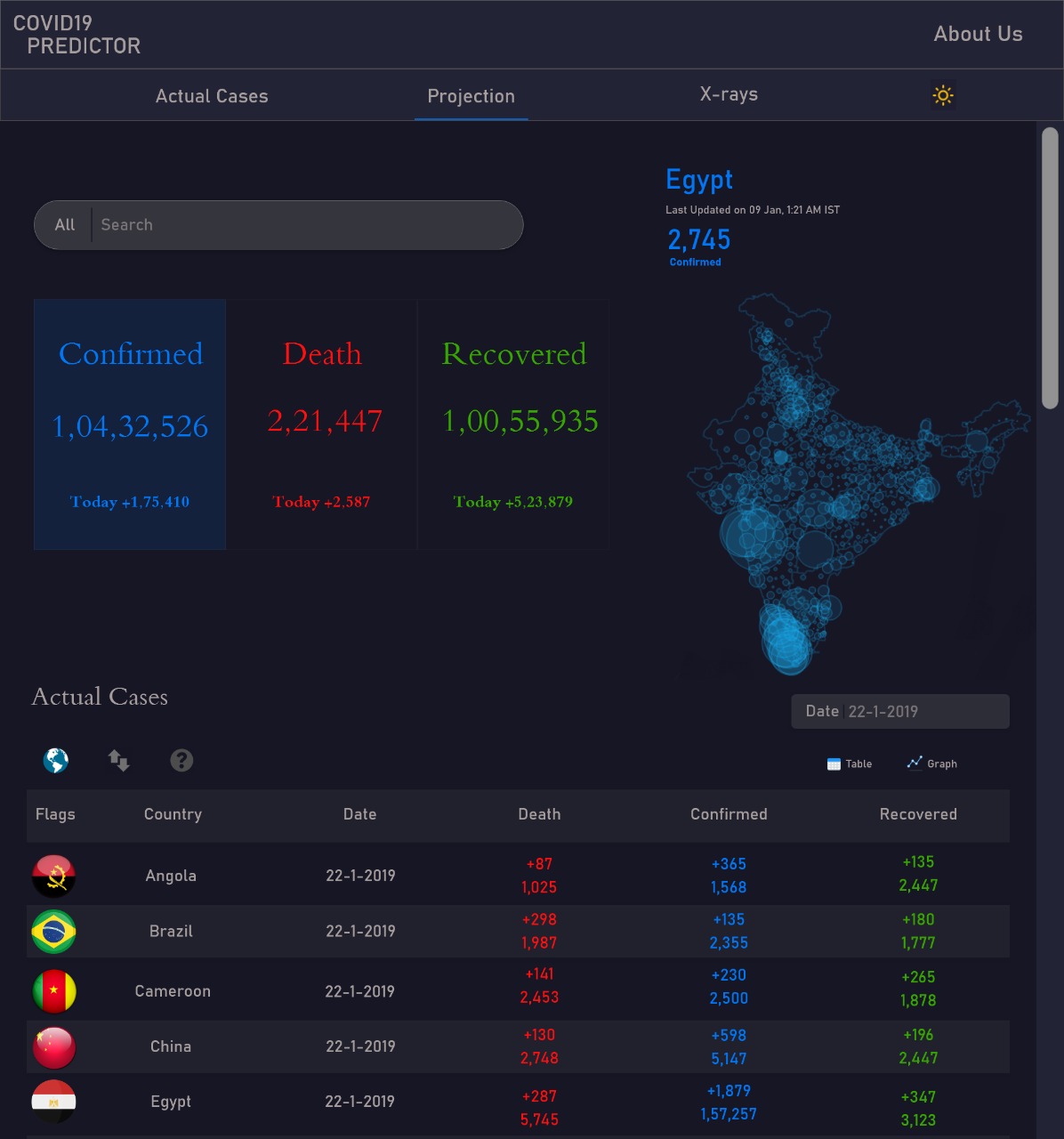
1. **Dark** **mode**



Figure 3: Dark mode design

# ***Chapter Five: Data Preparation***

## ***5.1. Objectives***

This study aims to cov-19 outbreak forecasting and investigate the relationship Between the features that we think it act as a very key factors on outbreak spreading like meteoritical conditions: average temperature, humidity, wind speed and another social factors like population contact.

## ***5.2. Methods and analysis***

Almost 500+ records of weather data with 7 meteorological features, namely, max temperature, min temperature, average temperature, sun hours, UV index, wind speed Km/ph., humidity, visibility, and another social data like date highlighting with appears to have occasion leads to increase the population mobility and human to human contact like Ramadan, Iftar Eid, Adha Eid. etc.

## ***5.3. Data Gathering***

The type of data to be obtained hove to contain statistics related to the number of confirmed infections with the Coronavirus and the number of deaths and the number of cases of recovery. These are data related to the virus itself and its effects. On the other hand, there are data on the describe the climate in general, which is the temperature And wind speed and humidity, which are expected to be factors that may affect the extent of the spread of the virus, in addition to the fact that the Coronavirus is infectious and depends strongly on the degree of human contact, we want to obtain any describer that provides us with knowledge of whether there is communication or potential strong contact between people or No.

## ***5.4. COV-19 statistics***

As for the of data related to COV-19 infection statistics, there are many sources that provide this type of data, the most common one is 2019 Novel Coronavirus operated by the Johns Hopkins University Center for Systems Science and Engineering (JHU CSSE) (find it at the following link: https://github.com/CSSEGISandData/COVID-19). Mainly for mostly all countries (which provide reliable channels for reporting its Epidemiological situation), this GitHub repository contains 3 statistics related to the COVID-19 pandemic, number of the confirmed cases, number of deaths, number of recovered, also the repository contains some statistics about vaccinations, but this data is irrelevant in our situation

## ***5.5. Meteorological Data***

The second type of required data to be obtained is the meteorological data related to a specific country. This type of data represented a major obstacle in finding such an open-source provider or any correct relevant dataset. Most of the available data is either specific to a country other than the country under study or actual (current) data and not a historical one and after long research, we reached out to worldweatheronline API, through which we were able to send HTTP calls to gain access to historical Egyptian climate data. This API can be accessed through the following link (https://www.worldweatheronline.com/developer/)

**Social Indicators**: The third type of data to be collected is the one that gives an indication of the potential of increased contact between people and social distancing lacking, and given that these data are local data specific to the country, finding them was difficult, and therefore this type was provided manually by highlighting the time periods at which people most likely to highly communicate with each other

## ***Chart, line chart Description automatically generated5.6. Data Preprocessing:***

using MS Excel as a lightweight software to manipulate date with user friendly user interface, a simple line chart is plotted corresponding Egypt confirmed COV-19 cases starts from 24/1/2020. It is obvious that Egypt has, it is worth noting that Egypt has a low number of infections relative to the rest of the world, especially in Europe and North America, and the country has also faced many peaks, almost 3 peaks since the beginning of the infection spread (highlighted in red)

Figure 4: Egypt COV-19 confirmed cases stats vs Time

Chart, line chart

Description automatically generatedIt is noticeable that if a long period is found in which the likelihood of people communicating with each other increases, then this period will follow a noticeable increase in the number of new infections with the virus. And this is what figure 2 depicts.

Chart, line chart

Description automatically generatedChart

Description automatically generatedBy discovering the third graph, which expresses a graph of the maximum temperature, it can be noted that the difference in temperature (decrease or rise) in temperature is offset by an increase in the number of new cases of infection recorded, and this can be explained by the fact that the Corona virus is one of the Coronaviruses, like other viruses such as seasonal influenza, infection increases in the winter or with it, especially with differences in temperature, which in turn affects scientifically the ability of the immune system of the human body. Also, viruses are known by their nature for their ability to coexist and multiply in low temperatures. Some studies indicate that the Corona virus cannot coexist at temperatures higher than 80 degrees Celsius

Figure 5: Egypt COV-19 confirmed cases stats vs Time

Figure 6: Egypt max temperature vs Time

## ***5.7. Data scaling***

|  |  |
| --- | --- |
| **5.7.1. Data smoothing:** to perform some of smoothing over the given signal we can use algorithms like moving average (MA) or Central Moving Average CMA to the time series observation, the resulting signal is smoothed signal with removed some outlier observations | Diagram  Description automatically generated |

Figure 7: confirmed cases and confirmed cases smoothed

|  |  |
| --- | --- |
| **5.7.2. Data Scaling:** to make faster training processing we perform min max normalization to all continuous observations to scale it to range from 0 and 1 and after perform forecasting, a reverse scaling process is done to reverse scale the output to it’s ordinary range. the following graphs depicts data after and before smoothing | Text  Description automatically generated with medium confidence |

Another new calculated attribute (is\_Increasing:Boolean) is presented as an increasing indicator if it set to 1, then the confirmed cases is increasing relative to day before and if 0 if mean it decrease relative to the day before

Figure 8: Confirmed and is\_Increasing Indicator

As the observations are collected at successive equally spaced points in time and time represent the independent variable x and all observations represent the dependent variable, so we have a time series data on hand. As we have a time series problem, you should select a forecasting model that can performs good at time series data.

# ***Chapter Six: Algorithms***

## ***6.1. Auto Regressive Integrated Moving Average [ARIMA]***

It is a time series model that use statistics to analyze and forecast time series data.

Before we enter in detail in ARIMA model we need to know what time series is.

**6.1.1. Time series**

Is a sequence of events happened in regular time may be [yearly, monthly, quarterly, weakly, hourly] it always depends on time.

* If you use only the previous values of the time series to predict its future values, it is called **Univariate Time Series Forecasting**.
* If you use predictors other than the series to forecast it is called **Multi Variate Time Series Forecasting.**

in our problem we use **daily** and multi variate time series forecasting.

Let’s discuss what is these abbreviations refer to:

* **AR**: stander for [Autoregression], It’s a relationship between observation some number of lagged observations
* **I**: stander for [Integrated], subtracting an observation from an observation at the previous time step to make the time series stationary.
* **MA**: stander for [Moving Average], it’s a relationship between an observation and a residual error from a moving average model applied to lagged observations.

All of these abbreviations specified in the model as parameters with integer values defined as follows:

* **p:** The number of lag observations included in the model, also called the lag order.
* **d:** The number of times that the raw observations are differenced, also called the degree of differencing and we choose the minimum number of differencing needed to make the series stationary, if the time series is already stationary, then d = 0.
* **q:** The size of the moving average window, also called the order of moving average.

before we apply the ARIMA model in our data we got this it’s not stationary graph so we need to apply the model on the data to be stationary

Graphical user interface, chart, line chart

Description automatically generated

Figure 9: non-stationary data

After we apply it we got this one

Chart, line chart

Description automatically generated

Figure 10: stationary data

Graphical user interface, chart, line chart

Description automatically generatedAnd it was satisfying to us to work with, then we forecast the future cases depending on the previous data and we got this graph

Figure 11: actual cases vs prediction cases

Table

Description automatically generatedWe tested our model and this is the results

The **accuracy** of the model was 65% it’s not bad but we realize after more search that corona depends on another factor not just the previous data of cases but also affects with

1. seasons like winter the flu increases
2. temperature there is a negative relationship between number of cases and temperature even the is low the cases will be high and vice versa.

So, depending on these reasons this model not suitable for our problem so we tried another one.

Table

Description automatically generated

Figure 12: Actual vs prediction cases

***6.2. Long Short-Term Memory [LSTM]***

This type of recurrent neural networks is commonly used in time series forecasting as its ability to remember specific sequence of time.

As neural networks are supervised learning models, they have to take some of data with hyper faradmeters (features) and corresponding label, during training after comparting the true label with arbitrary selected label the back propagation is done based on some of gradient descend function to tune the neurons weights that minimize the error between forecasting label and actual label, so we need to divide our data set into 2 category, one will represent the features and one will represent the label .

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data preparation:** LSTM need the data to be selected as a sliding window for example, selecting the index (0,1,2,3) of observation as a feature or hyper paraments and the index (4) as the corresponding label, by moving the sliding window one step forward, the new index including (1,2,3,4) of observations will acts as the features or another hyper parameter, and the index (5) will be the label. Etc, figure at the right demonstrate visually what does it looks like to prepare the data for training. | |  |  |  |  | | --- | --- | --- | --- | |  | Frame |  | Label | | 0 | 1 | 2 | 3 | | 1 | 2 | 3 | 4 | | 2 | 3 | 4 | 5 | | 3 | 4 | 5 | 6 | | 4 | 5 | 6 | 7 | | 5 | 6 | 7 | 8 |   Table 6: Egypt COV-19 confirmed cases LSTM |

After performing LSTM model trading, we can now use it in time series forecasting based on previous observations, but we can denote that we did not apply any hyper parament in model training, so we need some way to make feature dependent forecasting to add some of intelligent to the model and give more reliable statistics as we have a hypothesis that the COV-19 outbreak somehow depends on specific set of features. So, we divide our problem into 2 small problems, the first one is to make traditional time series forecasting, the second is to adjust the result to be more some features dependent.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Signal adjustment**: after performing traditional forecasting we apply some of adjustments over the resulting signal, the type of adjustment will be either raising or signal decaying this is decided based on the fed features this will be considered as simple binary classification model that will give either (1) which mean this will yield significant signal increasing or 0 which will yield do signal flatten of decaying, s sample of provides data set is shown at the right | |  |  |  | | --- | --- | --- | | weather | isOccasion | increasing | | 20 | 1 | 1 | | 40 | 1 | 0 | | 25 | 0 | 1 | | 15 | 1 | 0 | | 34 | 0 | 0 | | 17 | 1 | 1 |   Table : Egypt weather, is occasion indicator |

|  |  |
| --- | --- |
| *Regression Statistics* | |
| **Multiple R** | **0.901387953** |
| **R Square** | **0.812500241** |
| Adjusted R Square | 0.812152375 |
| Standard Error | 9.411203713 |
| Observations | 541 |

We did not consider the deaths and recovered cases as by nature they are correlated to confirmed cases, so as we have forecasted statistic about confirmed cases, we can infer the death cases and recovered cases, and to calculate the correlation between the confirmed cases and deaths cases, we first apply 7-day lag to recovered cases and apply linear regression model. The regression summary can be checked as table shows, we can see that there is a very strong linear relationship between confirmed cases and death cases as. We can also check the model variable significance by checking the p value in the ANOVA table, as P value of conf is too small < 0.05, so the model is significant

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ANOVA |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |
| Regression | 1 | 206872.1 | 206872.1 | 2335.67 | 4.5138E-198 |
| Residual | 539 | 47739.64 | 88.57076 |  |  |
| Total | 540 | 254611.7 |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | ***P-value*** | *Lower 95%* |
| Intercept | 6.362338961 | 0.642663 | 9.899965 | **2.42E-21** | 5.099908286 |
| conf | 0.04592829 | 0.00095 | 48.32877 | **4.5E-198** | 0.044061486 |

Table : Anova-1 table

The Residual plot also could be used to check the linear regression model assumptions validation.

Figure : conf Residual Plot

|  |  |
| --- | --- |
| *Regression Statistics* | |
| Multiple R | 0.866922 |
| R Square | 0.751554 |
| Adjusted R Square | 0.751088 |
| Standard Error | 11.25375 |
| Observations | 535 |

Also, for relationship between confirmed cases and recovered cases could be linear but with smaller value for R this could be interpreted to that not all people who have been recorded as confirmed cases are tent to visit the hospital once again to make sure they have recovered. By checking the ANOVA table, it’s obvious that model is still significant as whole and for independent variable (confirmed cases)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ANOVA |  |  |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |
| Regression | 1 | 204197.4 | 204197.4 | 1612.338 | 2.7E-163 |
| Residual | 533 | 67502.74 | 126.6468 |  |  |
| Total | 534 | 271700.2 |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* |
| Intercept | 6.373377 | 0.777545 | 8.196794 | 1.85E-15 | 4.845948 |
| Confirmed Cases | 0.045915 | 0.001143 | 40.15393 | 2.7E-163 | 0.043669 |

Table : Anova-2 table

The first model we have tried out is the basic LSTM model, as stated before, LSTM is a Recurrent neural network model which is commonly used for time series forecasting, LSTM is feeded with consecutive data frame, so we prepare the data with required expected shape, and start training the model, after perform model training, we perform model testing, as everything seem to be great, we found out that we haven't plug any potential controlling hyper parameters during model training.

Moving from the idea of using LSTM to the idea of using regression model. By having 2 hyper parameters and confirmed cases we could build a regression model to forest the new confirmed cases, but we tried to adapt the idea of using the sliding window. We add extra 4 columns each one represents a confirmed cases with lag equal to one day of the previous one, so we have a row on which the confirmed cases at this day is represented plus the day before that day and day before 2 days that day and so on. It was a good idea but not flexible. As whenever the sliding window size is tented to be changed, the while data frame must be manipulated once again. Also, the time sensitivity was lost

## ***6.3. Random Forest Regressor***

The general idea of the bagging method is that a combination of learning models increases the overall result.

The random forest is **a classification algorithm consisting of many decision trees**. It uses bagging and feature randomness when building each individual tree to try to create an uncorrelated forest of trees whose prediction by committee is more accurate than that of any individual tree.

Graphical user interface, chart, application, line chart

Description automatically generated

this chat has the prediction of new cases and the actual new cases from 20/4/2021 to 9/5/2021

## ***6.4. Ada Boost Regressor***

An AdaBoost regressor is a meta-estimator that begins by fitting a regressor on the original dataset and then fits additional copies of the regressor on the same dataset but where the weights of instances are adjusted according to the error of the current prediction. As such, subsequent regressors focus more on difficult cases.

Chart, line chart

Description automatically generated

this chart has the prediction of new cases and the actual new cases from 20/4/2021 to 9/5/2021

## ***6.5. linear regression***

Linear regression is one of the most commonly used predictive modelling techniques. It is represented by an **equation 𝑌 = 𝑎 + 𝑏𝑋 + 𝑒**, where a is the intercept, b is the slope of the line and e is the error term. This equation can be used to predict the value of a target variable based on given predictor variable(s).

Graphical user interface, application

Description automatically generated

this chart has the prediction of new cases and the actual new cases from 20/4/2021 to 9/5/2021

## ***6.6. Moving Average***

Graphical user interface, histogram

Description automatically generatedThe predicted value for each day will be the average of a set of previously observed values. Instead of using the simple average, we will be using the moving average technique which uses the latest set of values for each prediction. In other words, for each subsequent step, the predicted values are taken into consideration while removing the oldest observed value from the set.

## ***6.7. k-Nearest Neighbors [KNN]***

Graphical user interface, application, histogram

Description automatically generatedBased on the independent variables, KNN finds the similarity between new data points and old data points.

## ***6.8. Naive Bayes [NB]***

Naive Bayes is one kind of data mining classification and used to predict number of cases, deaths and recovery based on old data in other world based on last number in the data of each attribute, for example

|  |  |  |
| --- | --- | --- |
| Date | New cases | Predictions |
| 1-1-2021 | 190 | - |
| 2-1-2021 | 155 | 190 |
| 3-1-2021 | 210 | 155 |
| 4-1-2021 | 213 | 210 |
| 5-1-2021 | 220 | 213 |
| 6-1-2021 | 215 | 220 |
| 7-1-2021 | 200 | 215 |

uses Bayes theorem for classification take the previous day for future, so the accuracy of this algorithm very low for two reasons

1. Cause it depend on the past data.
2. Not depend on factors affecting such as temperature and occasions, etc.

## ***6.9. Susceptible infected recovered [SIR]***

* **The susceptible state**: refer to person doesn’t have corona at time t , but contact with a person infected with the corona so may be infected
* **The infected state**: refers to an person who has a corona at time t and may infect a  
  susceptible individual “if they contact with each other”
* **The recovered state**: refer to person who is recovered or dead from corona at time t

The number of deaths is counted in the recover state because an epidemiological point of view, this is basically the same thing, regardless of whether recovery or death does not have much impact on the spread of the disease

Used to analyze and predict the number of infected persons and the number of recovered persons (including deaths) have two time invariant:

**The transmission rate β** means the average beta for each person contact with others randomly per time.

**The recovering rate γ** is a fixed average rate of recover or infected individuals in affected States

we use beta and lambda to predict the number of the infected persons and the number of recovered persons at a certain time t in the future, used them to calculate R0 is function of time calculated by R0 is simply β/γ.

if person have corona takes 1/γ “on average” days to recover and during that period will be connect with β “on average” persons.

R0 is the number of additional infections by an infected person before it recovers, is one of the commonly used metrics to check whether the disease will become an outbreak, if R0(t) > 1, the disease will spread exponentially and infects a certain fraction of the total population.

S(t) is the number of susceptible persons at time t, X(t) is the number of infected persons at time t and R(t) is the number of recovered persons at time t, to make prediction by SIR model we use Differential Equations to S(t), X(t) and R(t).

N is populations is summation S(t), X(t) and R(t).

N= S(t) + X(t) + R(t)

γX(t)

And to calculate the probability of β and γ

β(t) =

γ(t)=

we used this calculation to predict the future the accuracy is 74% but the problem in SIR model is depend on the probability such as β and γ that’s inaccurate to put probability of connecting with other and if he have corona or not can’t be more accurate to use it and the result not accurate the second problem traditional SIR not depend on factors such as temperature and the adjust of this model use factors in the form probability .

## ***6.10. Resnet18***

resne18 is kind of deep learning method (DL), automatically is extracts features from data then performs classification of an image the most advantage of DL is the extractions and classification are performed in the same network. We use this model to classify the images and make analysis on it to know is this image corona or not.

Resnet18 is convolution neural network [CNN] model it’s the state-of-the-art DL technique have many stacked convolutional layers to extracts feature automatically from image data the layers used to build CNN, that use 18 layers that are fully connected to each other to know all things happen in each layer

Chart, diagram

Description automatically generated

Figure 14: fully connected nodes

The stacked layers are:-

1. Input layer
2. Convolution layer (main layer)
3. Pooling layer (main layer)
4. Rectifier linear unit (ReLU) activation layer
5. Fully connected layer

Diagram

Description automatically generated

Figure 15: convolution vs pooling layers

1. Convolution layer:

It’s a layer that some linear calculations happen on the images that involves the multiplication of a set of weights with the input like we make a normalization for the image

1. Pooling layer:

After convolution calculations we choose the max number in the matrix and reduce the size of an image by keeping the high-level features

1. Rectifier linear unit (ReLU) activation layer:

activates the neurons above a threshold value

1. Fully connected layer:

produce the result

**Transfer learning [TL]**

in transfer learning we make train for data to learn features in a board domain, we choose resnet18 although there are resnet50 and more models , resnet18 is better because of its relatively shallow architecture, and it can train the images faster without compromising performance.

consist of:

1. 7\*7 convolutional layer
2. 2 pool layers
3. 5 residual blocks (3 ×3 convolutional layers followed by a batch normalization layer and a ReLU activation function)
4. one FC layer

Diagram

Description automatically generatedThis is how resnet18 work for all images

Figure 16: Resnet18 architecture

![Diagram

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4SeIRXhpZgAATU0AKgAAAAgABgALAAIAAAAmAAAIYgESAAMAAAABAAEAAAExAAIAAAAmAAAIiAEyAAIAAAAUAAAIrodpAAQAAAABAAAIwuocAAcAAAgMAAAAVgAAEUYc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFdpbmRvd3MgUGhvdG8gRWRpdG9yIDEwLjAuMTAwMTEuMTYzODQAV2luZG93cyBQaG90byBFZGl0b3IgMTAuMC4xMDAxMS4xNjM4NAAyMDIxOjA3OjE5IDIwOjEwOjE0AAAGkAMAAgAAABQAABEckAQAAgAAABQAABEwkpEAAgAAAAMwMAAAkpIAAgAAAAMwMAAAoAEAAwAAAAEAAQAA6hwABwAACAwAAAkQAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Figure 17 :Resnet18 architecture (flowchart)

And We split our data into train set and test set then we put the train set in the model to learn from it and get all feature to know how to forecast new image that wasn’t see before

This is before we apply the model, it can’t detect the image and the result was so bad

A picture containing text, screenshot

Description automatically generated

But after we trained the model, this is the result we got and it was good

A picture containing text, different, screen, old

Description automatically generated

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