TMP-21_081

Sri Lanka Institute of Information Technology

Project Topic Assessment – 2021

Topic

Behavior Analysis for Depression Detection

Abstract (200 Words Max):

Depression is a chronic mental condition that requires immediate medical and psychiatric consideration. Although depression is not curable, it can remit with effective treatments. Detecting the early symptoms of depression is very important to help the affected individual to get medical treatment. Currently, the mental health industry has no reliable diagnostic laboratory tests for depression, and clinicians are much more likely to assess mental health using the series of standard questions to detect and treat depression. Technological involvement could be more advance in diagnosing depression.

Currently, the mobile applications associated with depression are using standard questionnaires to assess the depression level. In Sri Lanka, people may obscure the state of their mind due to social stigma and fear. However, a self-awareness mobile application that can evaluate own mental health and identify early depression symptoms, can be more valuable to remit the danger.

This study aims to develop a mobile application to analyze the unexpected behavior changes that might have a high chance of having depression. The results are evaluated by tracking social media activities, upper body movement patterns, phone usage, sleep efficiency and heart rate variability that are collected from individuals and analyzing them using machine learning algorithms, image processing and computer vision techniques.

Keywords: Computer Vision, Depression, Social Media and Text Content Analysis, Heart Rate Analysis, Sleep Analysis, Feature Extraction, Machine Learning, Image Processing, Adolescence

Research Area/Group: Select the area by referring to the document uploaded to the Courseweb

Visual Computing

Supervisor should fill this part

Supervisor: I certify here that co-supervisor and myself can guide this students to acquire required knowledge skills and attitudes pertaining to above sub domains of his/her specialization.

Supervisor: **Dr. Pradeepa Samarasinghe**

| **Dr. Pradeepa Samarasinghe** |
| Signature |

Continuation of Previous Year Project? ☐

If yes, state the Project ID

and year

| |

Co-Supervisor: **Ms.Vijani piyawardana**

| **Ms. Vijani Piyawardana** |

External Supervisor

| **Ms. Shalindi Pandithakoralage** |

Team Members:

Student Name	Student ID	Specialization
Leader: Oshadi Yashodhika G. B.	IT18120226	IT
Member 2: De Silva L. S. R.	IT18113914	IT
Member 3: Chathuranga W. W. P. K.	IT18119572	IT
Member 4: Liyanage D. R. Y.	IT18119718	IT

Research Problem:

Mental health disorders like major depressive disorder or anxiety disorder have been increasing rapidly among the younger generation due to various reasons. As a result of this, suicide rates have been rising among young people [1]. Even these mental illness causes life damages, people are not confident enough to believe that they are suffering from depression or anxiety within the impact coming from the society. Also, the most critical part is not receiving medications to these mental problems by consulting a psychiatric or psychologist. However, we should identify the risk of having the depressive disorder in the early stages before starting medications. It is not an easy task to understand depression level by ourselves rather than a professional psychiatrist. With the issue of identifying the early-stage disorder, majority of the people do not have an idea that they are suffering from depression or not.

The standard methods used to identify depressed individuals are use of questionnaires or advanced medical testing systems for severe patients. These tests are available for the people who think they have depression, and they may have identified their symptoms at the high-risk level. When we consider these problems, we should have an easily accessible application with suitable scientific parameters to identify the people who are in risk of suffering from depression, in the early stages.

We can think of a mobile based solution as an easy access application since the new generation always tends to use mobile phone applications to make their daily tasks easier such as checking daily work, checking health status, etc. Most of the currently available mobile applications developed for mental health pretend to track the status of depression by using questions to understand the mental stage and suggest solutions for mood changes, sleep disorders and mind relaxation methods for patients [2].

Facial Expression

Monitoring the early depression symptoms is crucial as the individuals may obscure the state of mind due to social stigma and fear. Also, the mental health industry in Sri Lanka fronts a key concern of lacking acceptance of depression due to social stigma. Emotions can used to identify early depressive states in individuals, which are used by mental health professionals in the industry. Mental health professionals identify symptoms of depression by monitoring the behavior and using standard rating scales. Several studies evaluated depression detection by using different techniques. The studies were focused on detecting depression using upper body movement rather than identifying early depression symptoms.

J. F. Cohn et al. investigated facial and vocal behavior relation in diagnosing depression, which was the first automated facial image analysis and audio signal processing to assess depression. The study used the person-specific Active Appearance Model (AAMs), Manual Facial Action Coding System (FACS), and vocal prosody to detect depression [3]. D. Venkataraman et al. proposed a system to detect depression among college students. This study considered frontal face images of happy, contempt, and disgust face in the video frame to analyze the depression. Viola-Jones face detection algorithm used to extract faces from each image [4].

Few studies were analyzed the link between depression and upper body movement. S. Alghowinem et al. examined the head pose and movement patterns of depressed individuals compared to healthy subjects using clinically validated real-world data. The statical analysis on the head pose and movement patterns showed a significant difference between healthy and depressed individuals [5]. Feasibility of a cross-cultural method to assess depression severity was investigated by S. Alghowinem et al. The study based on temporal aspects of the eye gaze and head position of the participants by using video-recorded clinical interviews (Australian, US, German) from three different datasets (BlackDog, AVEC, Pittsburgh) [6]. J. Joshi et al. study explored the upper body movements and gestures for automatic depression analysis. Upper body movements and intra-facial movements were computed using Space-Time Interest Points (STIP) feature, while head movement analysis was assessed by selecting rigid facial fiducial points [7].

Treatments would be more effective if depressed individuals have self-awareness of the mental health. Mobile application, which includes emotion-based behavior analysis for depressive disorder, may help people for self-awareness on the mental health state. Generally, the existing mobile applications focused on tracking moods. The analysis might be more biased since it considers daily mood records logged by the end-user. A mobile application that eliminates sort of manipulation by analyzing upper body movement would accurately assess early depression signs. To the best of our knowledge, a similar approach of automated analysis on depressive disorder using unexpected behavior changes that might have a chance of having depression is not yet studied in Sri Lanka.

Social medial content

Mental wellbeing is becoming an ongoing epidemic in the Sri Lankan community since the deficiency of expert assistance, and community stigma limits mental care. Hence, depressed individuals are reluctant to get treated by engaging with mental care professional. The treatment limitations arisen from social stigma can eliminate with Social media behavior analysis for depression. Social media behavior can reveal extensive patterns that might be related to depressive disorder. An accurate analysis on social media may help monitoring early depression signs and get treated in advance. Although a medical examination indicates the general state of health of a patient, a specialist may use other aspects related to making a diagnosis of depression. Monitoring the early depression signs would be beneficial in reducing expensive and long-lasting treatment procedures.

Previous studies were based on social media content to detect depression rather than identifying early depression signs. De Choudhury M et al. demonstrated a statistical model to estimate depression risk through the Twitter activities of the users. English-speaking Twitter users considered measuring and predicting depression in individuals. The study Proposed the SVM classifier using behavioral cues (linguistic styles, depressive language, ego network, etc.) to estimate the depression risk with an accuracy of approximately 70% [8]. Tsugawa et al. investigated a method to recognize depression using various features (frequencies of word usage, the ratio of positive/ negative affect words, number of users following, number of users followed, etc.) obtained from Twitter history activities [9]. The study extended the De Choudhury M et al. prediction framework to Japanese-speaking Twitter users [8].

C. S. A. Raza et al. focused on developing a web application to analyze posts of Twitter users for detecting personal depression attitude using machine learning. The study used three different techniques (Naive Bayes Classifier technique, NLP techniques, Deep Learning technique) to analyze the depression risk by considering positive and negative tweets [10].

Few studies examined the link between depression and social media activities. The effectiveness of using language and behavior data from social media to assess depression has been shown in these studies. Md. Rafiqul Islam et al. focused on analyzing depression through the Facebook activities of the users. The study observed the decision tree algorithm as the highest accuracy in emotional process and linguistic style comparing to other machine learning techniques (KNN, SVM, Ensemble). Facebook comments were considered in predicting depression among Facebook users [11]. Schwartz et al. studied a shortlist of words, topics, phrases to analyze depression. Further, the study focused on seasonal fluctuations of depression [12].

Depressed individuals with self-awareness would receive effective therapy for mental health. A mobile application, which analyzes the social media behavior to identify depressive disorder early signs, may help the individual to have self-awareness on mental health. Generally, the existing mobile applications focused on self-monitoring of depressive signs by analyzing the user logged information on questionnaires. The analysis might be more biased since the data is providing the user. Few mobile applications include Chatbot to have the conversation with individuals. However, conversation content is not analyzing to recognize depressive symptoms. According to the above literature, an approach of automated analysis of depressive disorder by identifying early depression signs using social media is not yet researched in Sri Lanka.

Wearable data

Early-stage identification of depressive disorder is critical, because most Sri Lankan individuals endeavor to hide the symptom and avoiding medications with the social impact. When it comes to identifying depression, individual's mental health professionals use standard rating scales and advanced methods for severe individuals. Biometrical data from individuals obtained by wearables and non-wearables, can be crucial to identify depression patients. Because of that, the researchers have focused more on biometrical data such as, heartbeat, sleep patterns, skin temperature, and mobility to study symptoms of depression.

One of the most frequent physical changes of a depressive patient is sleep, in the research Epidemiology of insomnia by Maurice M Ohayon have mentioned approximately 80% of individuals with a current major depressive episode have co-occurring sleep difficulties [13]. Besides sleep patterns, heart rate is another physical factor that we can recognize in depression patients therefore the research from the South China University of Technology, Guangzhou with Danni Kuang et al. proved Depression patients have lower HRV than healthy subjects. Therefore, HRV may be used to distinguish depression patients from healthy people by using Bayesian Networks [14].

A study from the Faculty of Science and Technology, Keio University, Kanagawa, Japan have developed a machine-learning algorithm to screen for depression and assess severity based on data from the wearable device [15]. Furthermore, by Dartmouth College USA researched about track depression using an app and wearable data they took heart rate through warble and some other parameters like sleep details, mobility through the app called The Student Life [16]. There is a study from Media Lab, MIT, Cambridge, MA predicting the Hamilton Depression Rating Scale (HDRS) using data captured from E4 wearable wristbands and sensors in an Android phone [17].

Summing-up, the existing studies have focused on show links between depression and biometrics, develop an algorithm to monitor depression using wearable data, and predict depression with wearable data. Most of the studies have acquired wearable data and but there can be people who refuse to use wearables. Therefore, the development of a mobile application that includes biometrical data obtained using invasive and non-invasive techniques to behavior analysis for depressive disorder, may help people for self-awareness on the mental health state. To the best of our knowledge, studies have not been found in Sri Lanka that focused on a similar approach of automated analysis on depressive disorder identification using unexpected behavior changes.

Phone Usage data

Early-stage depression identification is crucial for treatments but Sri Lankan individuals that suffer from depression commonly moved on hiding symptomatic behaviors and decline the medications with the fear of social scaling towards mental disorders. Mental health professionals use behavioral changes of the individuals and standard rating scales. Technological impact on daily basis is getting more intensive. Therefore, researchers have discovered depression individual can be recognized using an individual's phone usage activities since depression and phone usage are bidirectional factors.

Studies have proved that high phone usage among students and depression links together positively, some of them are study by Kadir Demirci et al. "Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students" [18], The research "Relationship between the Manner of Mobile Phone Use and Depression, Anxiety, and Stress in University Students" by Aleksandar Višnjić, Vladica Veličković et al. [19] and the study by Sara Thomée et al. "Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults" [20].

Furthermore, School of Health and Social Development, Deakin University has researched to evaluate the relationship between the duration of time spent using the Internet for leisure, depressive symptoms among Australian adolescents they have showed depressive symptoms were most frequent among higher users of the Internet (3 or more hours per day) among females only Compared to adolescents reporting Internet use for two hours or less [21]. Addiction to social media can reflect suffering from depression disorder. The study by Amit Chowdhry shows that compare to people who use social media less frequently participants that use social media very frequently have 2.7 times the likelihood of depression and compared to people that spent less time, participants that spent the most total time on social media throughout the day had 1.7 times the risks of depression [22].

When it comes to app development for depression using phone usage data, we can find a study by Rafail-Evangelos Mastoras1, Dimitrios Iakovakis1, et al. track depression using Touchscreen typing pattern analysis data from TypeOfMood app [23]. There is a study from Dartmouth College, USA to tack depression using a mobile phone and wearable they took overuse phone usage from Student Life app as a factor to track depression [16].

In conclusion, most of the existing studies have proposed to prove the link between depression and phone usage and track depression symptoms according to phone usage data acquired using mobile apps. It will be an effective move if we can develop a mobile application that includes phone usage data obtained using phone activities log to behavior analysis for depressive disorder, may help people for self-awareness on the mental health state. In Sri Lanka studies have not been observed that concentrated on a similar approach of automated analysis on depressive disorder identification using unexpected behavioral shifts.

References

[1] K. M. Keyes, D. Gary, P. M. O'Malley, A. Hamilton and J. Schulenberg, "Recent increases in depressive symptoms among US adolescents: trends from 1991 to 2018," Social Psychiatry and Psychiatric Epidemiology, vol. 54, no. 8, pp. 987-996, 2019.

[2] J. Thomas, "The Best Mental Health Apps For Depression, Anxiety & Beyond," 2020.

[3] J. F. Cohn, T. S. Kruez, I. Matthews, Y. Yang, M. H. Nguyen, M. T. Padilla, F. Zhou and F. De la Torre, "Detecting depression from facial actions and vocal prosody," 2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops, 2009.

[4] V. D and S. P. Namboodiri, "A computer vision based image processing system for depression detection among students for counseling," Indonesian Journal of Electrical Engineering and Computer Science, vol. 14, no. 1, p. 503, 2019.

[5] S. Alghowinem, R. Goecke, M. Wagner, G. Parkerx and M. Breakspear, "Head Pose and Movement Analysis as an Indicator of Depression," 2013 Humaine Association Conference on Affective Computing and Intelligent Interaction, 2013.

[6] S. Alghowinem, R. Goecke, J. F. Cohn, M. Wagner, G. Parker and M. Breakspear, "Cross-cultural detection of depression from nonverbal behaviour," 2015 11th IEEE International Conference and Workshops on Automatic Face and Gesture Recognition (FG), 2015.

[7] J. Joshi, R. Goecke, G. Parker and M. Breakspear, "Can body expressions contribute to automatic depression analysis?," 2013 10th IEEE International Conference and Workshops on Automatic Face and Gesture Recognition (FG), 2013.

[8] M. de Choudhury, M. Gamon, S. Counts and E. Horvitz, "Predicting Depression via Social Media," Seventh Int. AAAI Conf. Weblogs Soc., 01 July 2013.

[9] S. Tsugawa, Y. Kikuchi, F. Kishino, K. Nakajima, Y. Itoh and H. Ohsaki, "Recognizing Depression from Twitter Activity," Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, 2015.

[10] C. S. A. Razak, M. A. Zulkarnain, S. H. A. Hamid, N. B. Anuar, M. Z. Jali and H. Meon, "Tweep: A System Development to Detect Depression in Twitter Posts," Lecture Notes in Electrical Engineering, pp. 543-552, 2020.

[11] M. R. Islam, M. A. Kabir, A. Ahmed, A. R. M. Kamal, H. Wang and A. Ulhaq, "Depression detection from social network data using machine learning techniques," Health Information Science and Systems, vol. 6, no. 1, 2018.

[12] H. A. Schwartz, J. Eichstaedt, M. L. Kern, G. Park, M. Sap, D. Stillwell, M. Kosinski and L. Ungar, "Towards Assessing Changes in Degree of Depression through Facebook," Proceedings of the

Workshop on Computational Linguistics and Clinical Psychology: From Linguistic Signal to Clinical Reality, pp. 118-125, June 2014.

[13] M. M. Ohayon, "Epidemiology of insomnia: what we know and what we still need to learn," Sleep Medicine Reviews, vol. 6, no. 2, pp. 97-111, 2002.

[14] D. Kuang, "Depression recognition according to heart rate variability using Bayesian Networks," Journal of Psychiatric Research, vol. 95, pp. 282-287, 2017.

[15] Y. Tazawa, K.-c. Liang, M. Yoshimura, M. Kitazawa, Y. Kaise and A. Takamiya, "Evaluating depression with multimodal wristband-type wearable device: screening and assessing patient severity utilizing machine-learning," Heliyon, vol. 6, no. 2, 2020.

[16] R. Wang, W. Wang, A. daSilva, J. F. Huckins, W. M. Kelley, T. F. Heatherton and A. T. Campbell, "Tracking Depression Dynamics in College Students Using Mobile Phone and Wearable Sensing," Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, vol. 2, no. 1, pp. 1-26, 2018.

[17] A. Ghandeharioun†, S. Fedor†, L. Sangermano, D. Ionescu, J. Alpert, C. Dale, D. Sontag and R. Picard, "Objective Assessment of Depressive Symptoms with," 2017.

[18] K. Demirci, M. Akgönül and A. Akpinar, "Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students," Journal of Behavioral Addictions, vol. 4, no. 2, pp. 85-92, 2015.

[19] A. Višnjić, V. Veličković, D. Sokolović, M. Stanković, K. Mijatović, M. Stojanović, Z. Milošević and O. Radulović, "Relationship between the Manner of Mobile Phone Use and Depression, Anxiety, and Stress in University Students," International Journal of Environmental Research and Public Health, vol. 15, no. 4, p. 697, 2015.

[20] S. Thomée, A. Härenstam and M. Hagberg, "Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults - a prospective cohort study," 2011.

[21] E. Hoare, K. Milton, C. Foster and S. Allender, "Depression, psychological distress and Internet use among community-based Australian adolescents: a cross-sectional study," BMC Public Health, vol. 17, no. 1, 2017.

[22] A. Chowdhry , "Research Links Heavy Facebook And Social Media Usage To Depression," 2017.

[23] R.-E. Mastoras, D. Iakovakis, S. Hadjidimitriou, V. Charisis, S. Kassie, T. Alsaadi, A. Khandoker and L. J. Hadjileontiadis, "Touchscreen typing pattern analysis for remote detection of the depressive tendency," Scientific Reports, no. 1, 2019.

Solution proposed:

This research proposes a mobile-based application to analyze unexpected behavior changes that might have a high chance of having depression. The analysis is based on social media activities, upper body movement patterns, phone usage, sleep efficiency, and heart rate variability.

The emotion analysis combined with head movement pattern identification can detect depression with high accuracy than having any single one of them to detect depression. The analysis involves the implementation of multimodal fusion by concatenating facial movement dynamics and head movement dynamics. The analyzed result integrates with the mobile application for depression analysis on unexpected mood changes that might have a high chance of having depression.

The analysis involves Twitter activities and Facebook activities. Twitter activities and Facebook activities of the individuals at-risk will be mutually analyzed. Additionally, this study includes a ChatBot implementation to have a conversation with individuals and examine the conversation on unexpected mood changes that might have a high chance of having depression. The analyzed result integrates with the mobile application for depression analysis on unexpected mood changes that might have a high chance of having depression.

The physical data from invasive and non- invasive techniques which are changes of Sleep patterns, Heart rate will be used as high accuracy parameters to identify people suffering from depression. The analysis involves collecting required physical data using invasive and non- invasive techniques. Build method using collected data to identify risk to suffer from depression then analyzed result integrates with the mobile application for depression analysis on unexpected heart rate, sleep pattern changes that might have a high chance of having depression.

The mobile app usage data such as addiction with mobile games, social media apps, internet usage and mobile phone use before sleep can be used as high accuracy factors that can be collected from mobile phone to identify people suffering from depression. The solution proposed include a service to log key factor's mobile usage data and a mobile application. This mobile application is developed for depression analysis using unexpected phone usage patterns that might have a high chance of having depression. The log data will be analyzed by machine learning techniques and that result will be integrated with the proposed mobile application to provide a feedback to the user.

System Overview Diagram for the solution proposed. Recommended to draw using
draw.io. Note: This is not an activity/flow (UML) diagram

1. **Man components including the data sources, stakeholders, interaction among the stakeholders, etc.**
2. **Interconnection among the components**
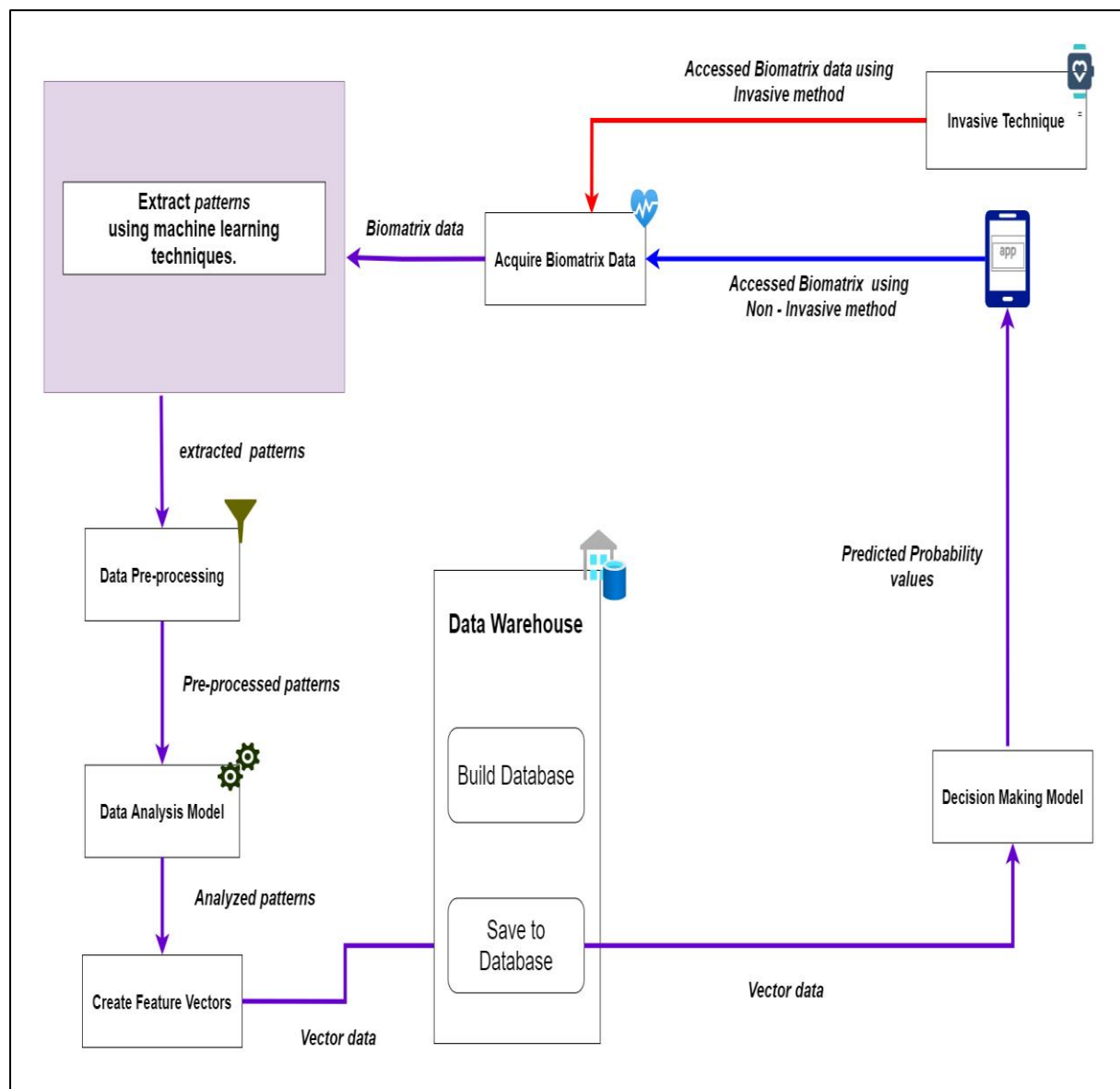3. **Major SW and HW components**
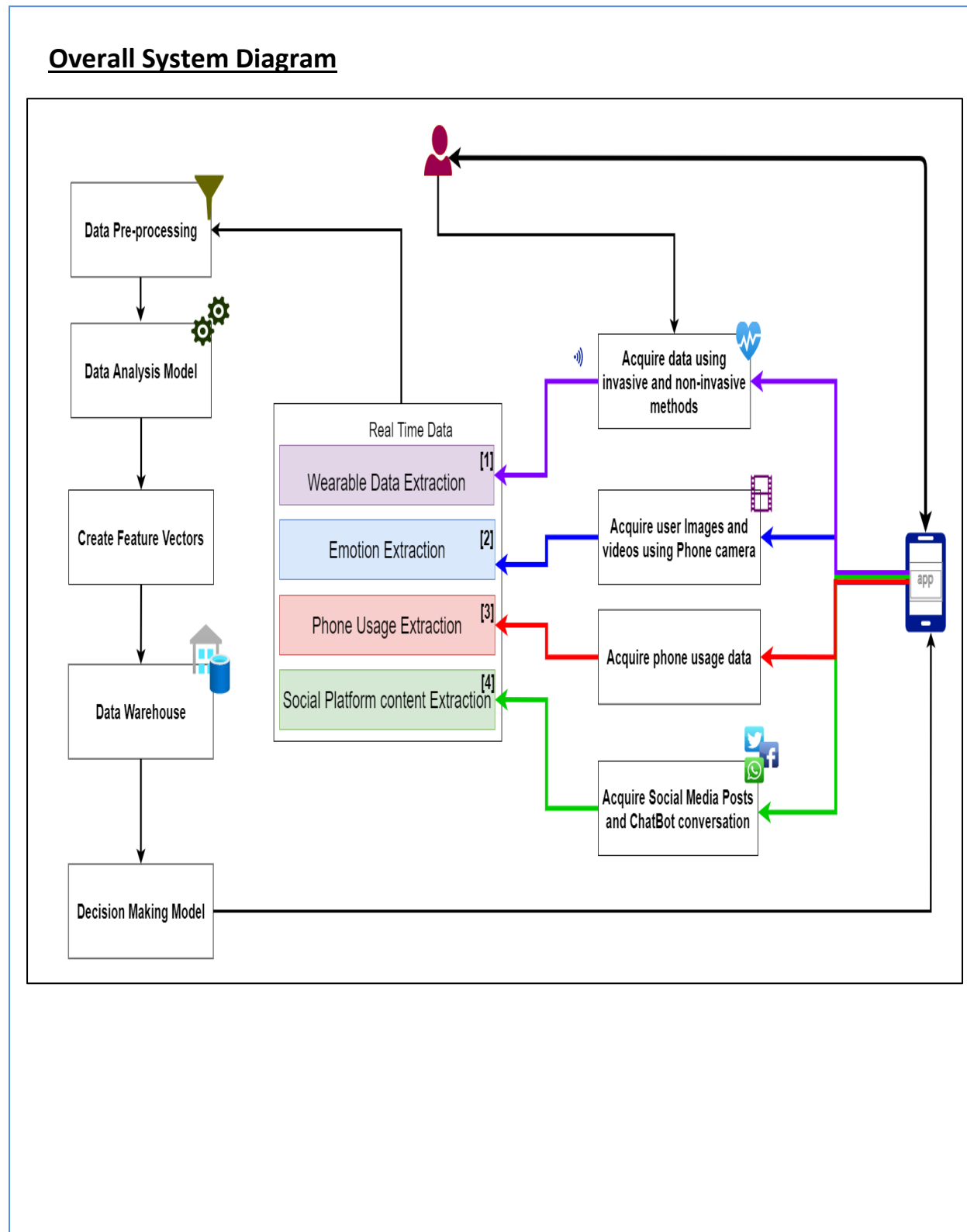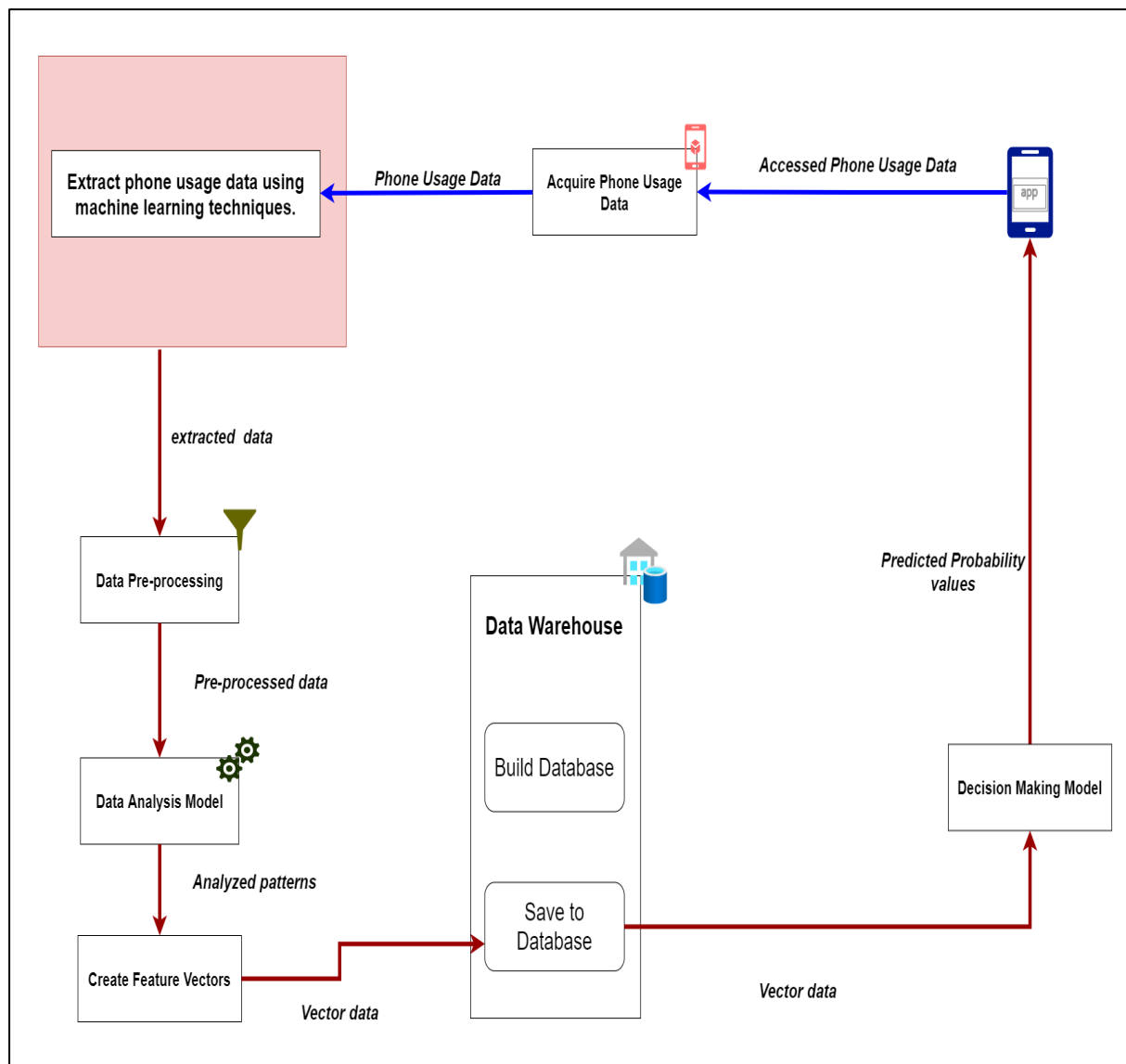
System Diagram for emotion-based analysis
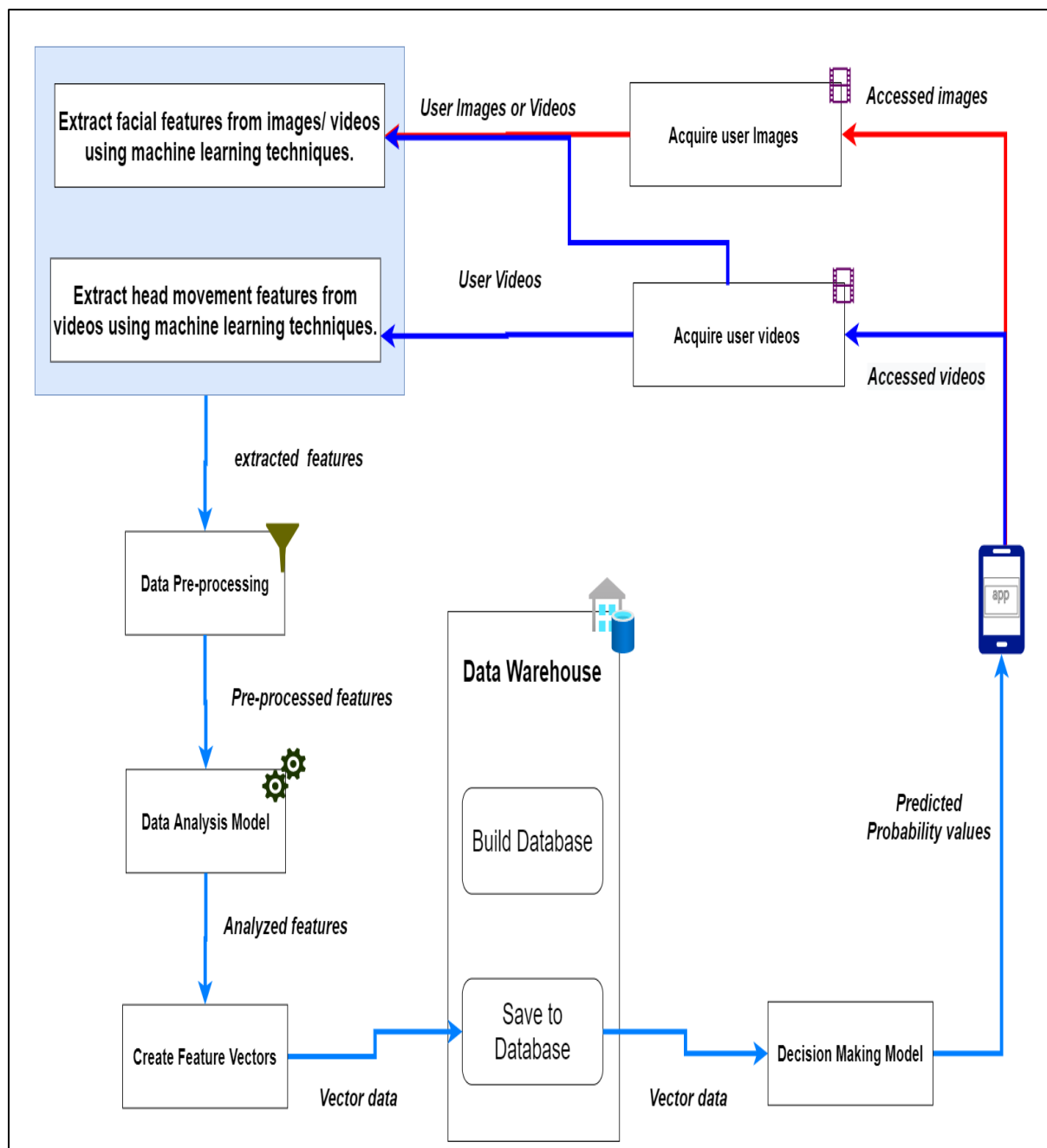
System Diagram for Social media content analysis
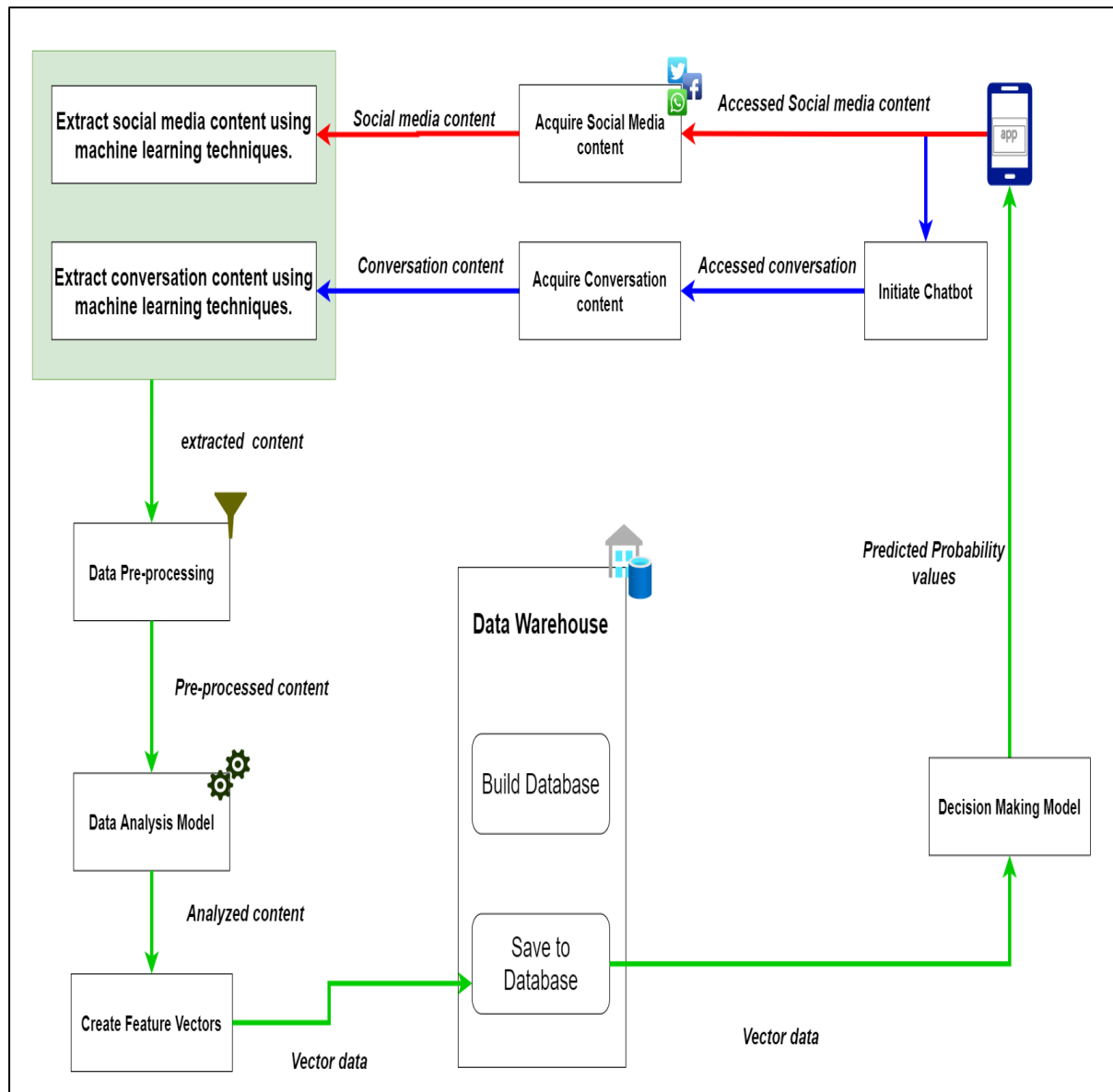
System Diagram for invasive and non-invasive data analysis

System Diagram for Phone data-based analysis

Extract phone usage data using machine learning techniques.

Phone Usage Data

Acquire Phone Usage Data

Accessed Phone Usage Data

app

extracted data

Data Pre-processing

Pre-processed data

Data Analysis Model

Analyzed patterns

Create Feature Vectors

Vector data

Data Warehouse

Build Database

Save to Database

Vector data

Predicted Probability values

Decision Making Model

Objectives (1 main objective and 4 sub objectives):

Main Objective:
Develop a mobile application to identify behaviors that could be highly anticipated to contribute in depressive disorder.

Sub Objective 1: Emotion-based behavior analysis for early identification of depressive disorder.

Sub Objective 2: social media content analysis for early identification of depressive disorder.

Sub Objective 3: Acquire invasive and non-invasive data analysis for early identification of depressive disorder.

Sub Objective 4: Obtain phone activity usage data analysis for early identification of depressive disorder.

Task divided among the members

Member 1 - Oshadi Yashodhika G. B.

Specific Objectives
1) Identify emotion based on Images and videos.
2) Identify head movements pattern on videos.
3) Build a classifier to model, abnormal behaviors based on facial emotions and head movements.
4) Predict the probability of abnormal behavior towards depression with the designed model
5) Integrate the classifier to Mobile Application.

Additionally,
6) Responsible for implementing interfaces.
7) Mobile Application development for facial movement and head movement analysis.

Member 2 - De Silva L. S. R.

Specific Objectives
1) Build a database based on Social Media Content.
2) Identify social media texting patterns based on the built database.
3) Build a classifier to model, abnormal social activities based on social media content.
4) Predict the probability of abnormal social activities towards depression with the designed model
5) Implement/ design ChatBot to initiate conversations, identify depressive thoughts based on conversations.

Additionally,
6) Responsible for integrating the model with the application.
7) Responsible for implementing interfaces.
8) Mobile Application development for social media analysis.

Member 3 - Chathuranga W. W. P. K.

Specific Objectives
1) Identify important health parameters.
2) Acquire wearable device collect required data and build a method to identify early-stage depressive disorder physical changes.
3) Build method using a non-inventive technique to identify early-stage depressive disorder physical changes.
4) Predict the probability of abnormal physical changes towards depression with the designed models.
5) integrate both models into the mobile app.

Additionally,
6) Responsible for implementing interfaces.
7) Mobile Application development.

Member 4 - Liyanage D. R. Y.

Specific Objectives
1) Identify the key factors of phone usage to identify depressive disorder changes.
2) Build a service to run in the mobile in order to log the key factor's data.
3) Based on data build a classifier to model, abnormal phone use based on mobile phone usage.
4) Predict the probability of abnormal phone use towards depression with the designed model
5) Integrate the classifier to the mobile app.

Additionally,
6) Responsible for implementing interfaces.
7) Mobile Application development.

Technologies to be used:

Flutter (Mobile Development)
 Python
deep learning
Pytorch
TensorFlow

If supervisor States that this year is a continuation of previous work, state the further work the students should do compared to the previous years.
(NOTE: This part has to be filled by the supervisor)

This part will be filled by the Topic Screening Panel members

Acceptable: Mark/select as necessary

Acceptance/ Rejection	Correction State	
	Minor Correction	Major Corrections
Accepted	☐	☐
Resubmit	☐	☐
Rejected	☐	

Corrections (if necessary)

Any other Comments:

_____

_____

_____

Approved by the review panel:

Member's Name	Signature

Important:

1. According to the comments given by the panel, do the necessary modifications and get the approval by the **same panel**.
2. If the project topic is rejected, find out a new topic and inform the CDAP Group for a new topic pre-assessment.
3. A form approved by the panel must be attached to the **Project Charter Form**.

Appendix 1

Appendix 2