Mental and Physical Illness (MAPI) Chatbot

Tusheet Goli, Tejas Pradeep, Akshay Sathiya, Pranav Khorana, Sanket Manjesh, Rahul Chawla
tgoli3@gatech.edu, tpradeep8@gatech.edu, asathiya6@gatech.edu, pkhorana3@gatech.edu, smanjesh3@gatech.edu, rchawla36@gatech.edu

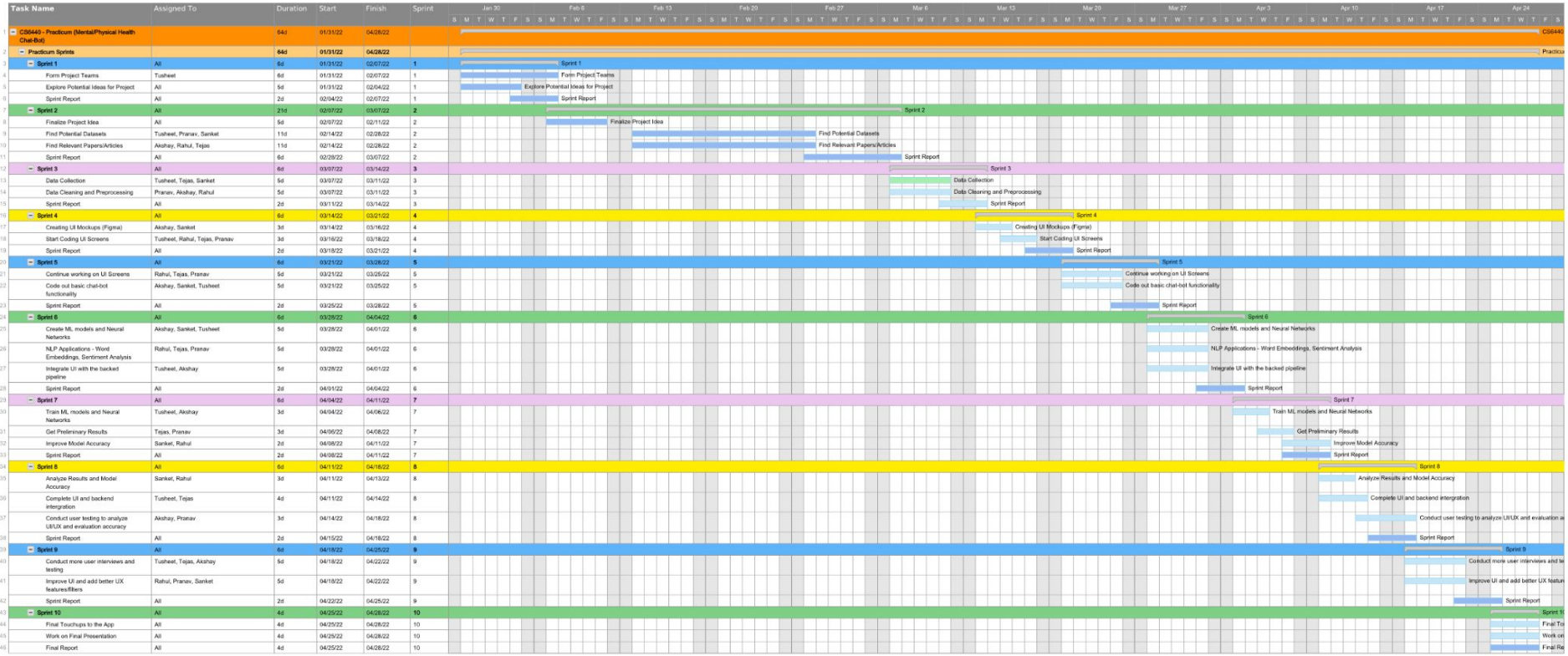
Introduction

- Definitions
  - Physical illness: illnesses pertaining to one’s physical health (common cold, flu, etc.)
  - Mental illness: illnesses pertaining to one’s mental health (anxiety, depression, etc.)
- Problem
  - People may not be able to immediately consult primary healthcare provider upon experiencing symptoms of mental or physical illness.
  - Determining illness risks helps them know if a doctor’s visit is required how to better take care of themselves.
- Solution
  - Mental and Physical Illness Chatbot

Introduction

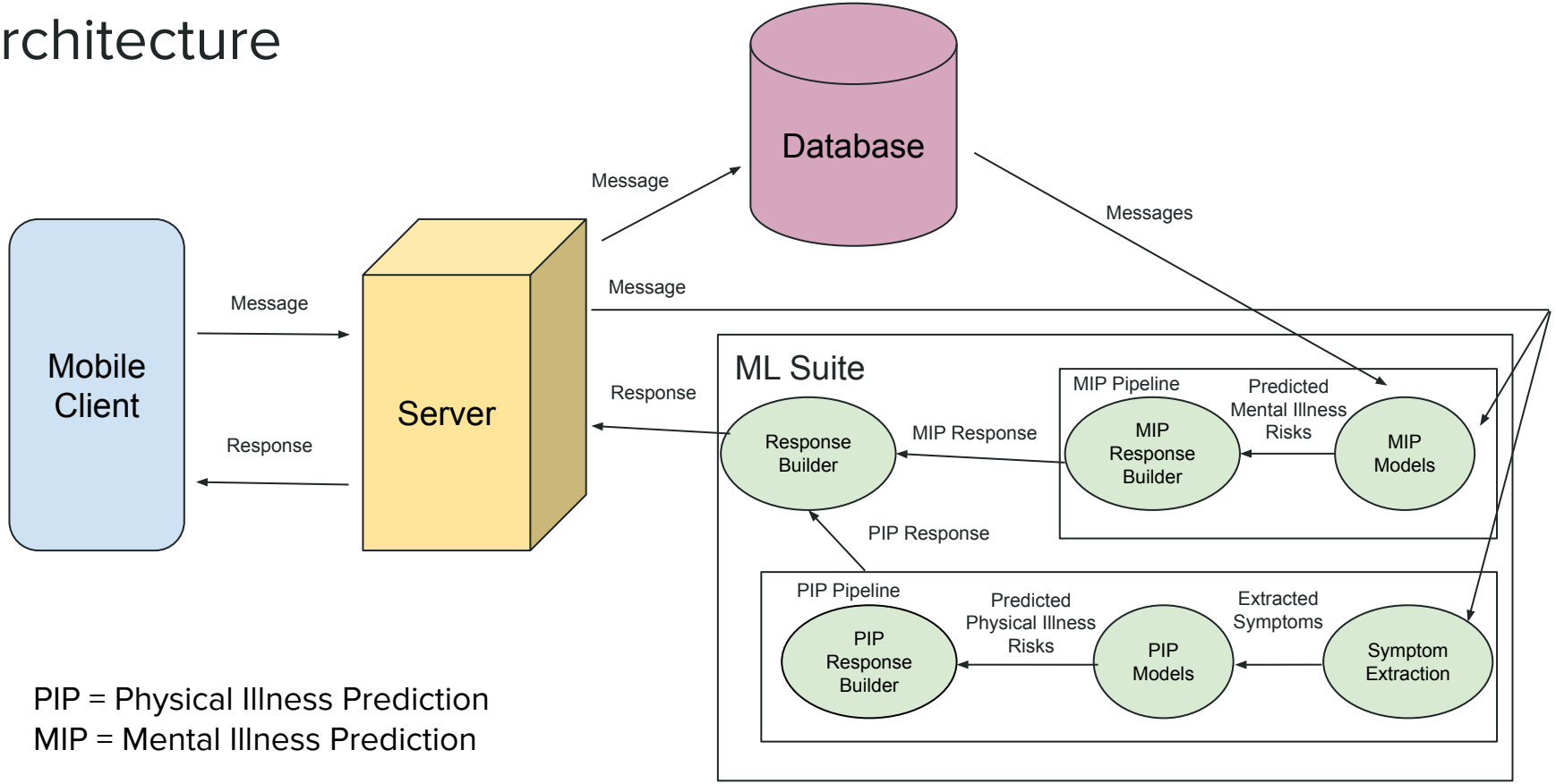
- Team contributions
  - Akshay Sathiya: Data processing for Kaggle physical diseases dataset (Patil, 2020), physical illness prediction (PIP) pipeline, and the PIP response builder to generate messages containing physical illness prediction results and precautions to send back to user.
  - Pranav Khorana: Created front-end React Native application and integrated w/ backend
  - Tusheet Goli: Worked on API design, backend implementation, and database hosting (Heroku)
  - Tejas Pradeep: Worked on the backend API design, and integrated front end w/ model
  - Rahul Chawla: Worked on the mental illness prediction (MIP) pipeline, created the logistic regression model and data processing for emotions dataset (Praveen, 2020)
  - Sanket Majesh: Worked on the mental illness prediction (MIP) pipeline

Project Implementation Status



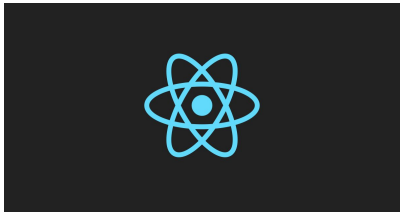
	Task Name	Assigned To	Duration	Start	Finish	Sprint
1	CS6440 - Practicum (Mental/Physical Health Chat-Bot)		64d	01/31/22	04/28/22	
2	Practicum Sprints		64d	01/31/22	04/28/22	
3	Sprint 1	All	6d	01/31/22	02/07/22	1
4	Form Project Teams	Tusheet	6d	01/31/22	02/07/22	1
5	Explore Potential Ideas for Project	All	5d	01/31/22	02/04/22	1
6	Sprint Report	All	2d	02/04/22	02/07/22	1
7	Sprint 2	All	21d	02/07/22	03/07/22	2
8	Finalize Project Idea	All	5d	02/07/22	02/11/22	2
9	Find Potential Datasets	Tusheet, Pranav, Sanket	11d	02/14/22	02/28/22	2
10	Find Relevant Papers/Articles	Akshay, Rahul, Tejas	11d	02/14/22	02/28/22	2
11	Sprint Report	All	6d	02/28/22	03/07/22	2
12	Sprint 3	All	6d	03/07/22	03/14/22	3
13	Data Collection	Tusheet, Tejas, Sanket	5d	03/07/22	03/11/22	3
14	Data Cleaning and Preprocessing	Pranav, Akshay, Rahul	5d	03/07/22	03/11/22	3
15	Sprint Report	All	2d	03/11/22	03/14/22	3
16	Sprint 4	All	6d	03/14/22	03/21/22	4
17	Creating UI Mockups (Figma)	Akshay, Sanket	3d	03/14/22	03/16/22	4
18	Start Coding UI Screens	Tusheet, Rahul, Tejas, Pranav	3d	03/16/22	03/18/22	4
19	Sprint Report	All	2d	03/18/22	03/21/22	4
20	Sprint 5	All	6d	03/21/22	03/28/22	5
21	Continue working on UI Screens	Rahul, Tejas, Pranav	5d	03/21/22	03/25/22	5
22	Code out basic chat-bot functionality	Akshay, Sanket, Tusheet	5d	03/21/22	03/25/22	5
23	Sprint Report	All	2d	03/25/22	03/28/22	5
24	Sprint 6	All	6d	03/28/22	04/04/22	6
25	Create ML models and Neural Networks	Akshay, Sanket, Tusheet	5d	03/28/22	04/01/22	6
26	NLP Applications - Word Embeddings, Sentiment Analysis	Rahul, Tejas, Pranav	5d	03/28/22	04/01/22	6
27	Integrate UI with the backed pipeline	Tusheet, Akshay	5d	03/28/22	04/01/22	6
28	Sprint Report	All	2d	04/01/22	04/04/22	6
29	Sprint 7	All	6d	04/04/22	04/11/22	7
30	Train ML models and Neural Networks	Tusheet, Akshay	3d	04/04/22	04/06/22	7
31	Get Preliminary Results	Tejas, Pranav	3d	04/05/22	04/08/22	7
32	Improve Model Accuracy	Sanket, Rahul	2d	04/08/22	04/11/22	7
33	Sprint Report	All	2d	04/08/22	04/11/22	7
34	Sprint 8	All	6d	04/11/22	04/18/22	8
35	Analyze Results and Model Accuracy	Sanket, Rahul	3d	04/11/22	04/13/22	8
36	Complete UI and backend intergration	Tusheet, Tejas	4d	04/11/22	04/14/22	8
37	Conduct user testing to analyze UI/UX and evaluation accuracy	Akshay, Pranav	3d	04/14/22	04/18/22	8
38	Sprint Report	All	2d	04/15/22	04/18/22	8
39	Sprint 9	All	6d	04/18/22	04/25/22	9
40	Conduct more user interviews and testing	Tusheet, Tejas, Akshay	5d	04/18/22	04/22/22	9
41	Improve UI and add better UX features/filters	Rahul, Pranav, Sanket	5d	04/18/22	04/22/22	9
42	Sprint Report	All	2d	04/22/22	04/25/22	9
43	Sprint 10	All	4d	04/25/22	04/28/22	10
44	Final Touchups to the App	All	4d	04/25/22	04/28/22	10
45	Work on Final Presentation	All	4d	04/25/22	04/28/22	10
46	Final Report	All	4d	04/25/22	04/28/22	10

Architecture

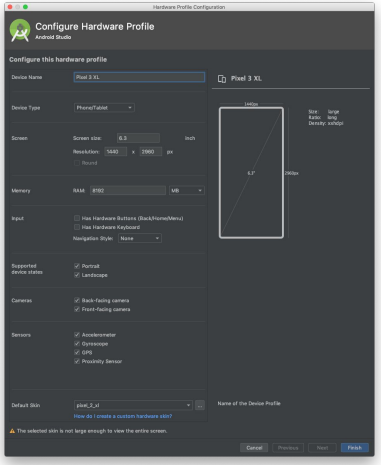


PIP = Physical Illness Prediction
MIP = Mental Illness Prediction

Setting Up Frontend



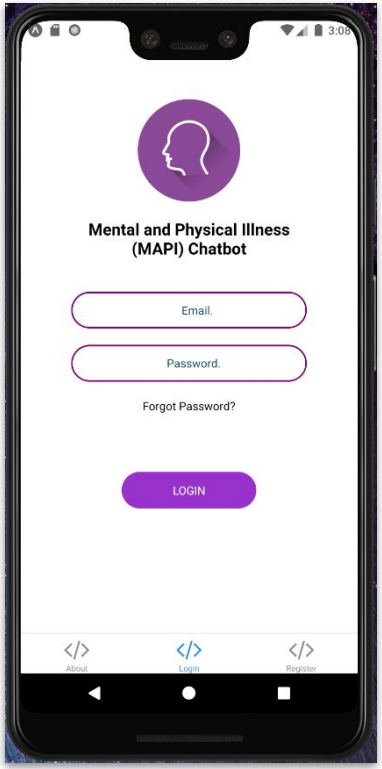
- Used React Native to create front-end application
  - Easy to deploy mobile apps on both Android and iOS operating systems
  - Utilized Javascript with Typescript configuration
- Android Emulator for testing and debugging
  - Pixel 3 XL with Android 8.0 operating system
- Utilized Expo, a framework that allows users to easily develop, build, and deploy React Native apps

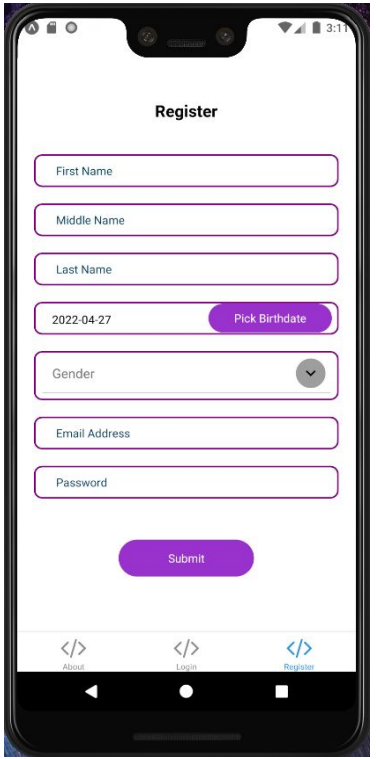


Creating React Native App

- React-Navigation and Bottom TabNavigator
  - Organized hierarchy for user to navigate (logging in and out/switching tabs)

- TextInput, Touchable Opacity, Dropdown, DateTime Picker
  - Utilized a variety of components for user to input info
  - Registering and logging in

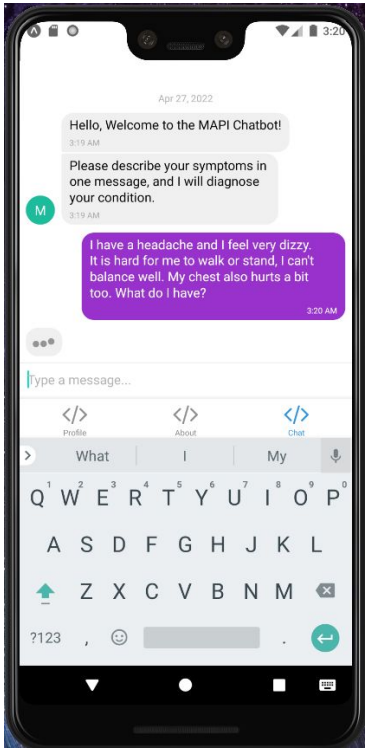


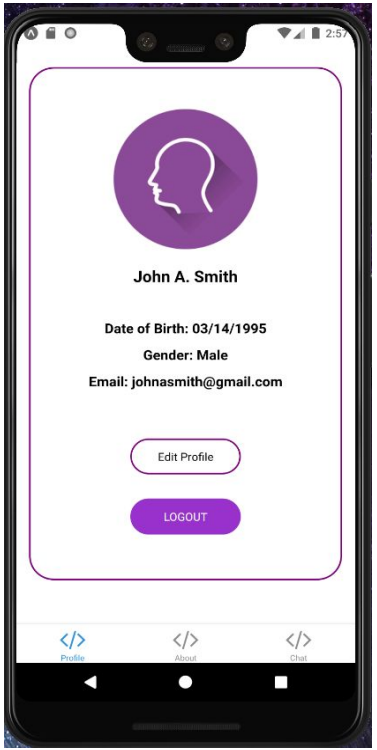


Creating React Native App

- Hooks to keep track of state & lifecycle components
  - useState: keep track of info (ex: name, date of birth, email, etc.)
  - useEffect: side effect based on rendering of components (ex: initial population of profile screen)

- React-Native-Gifted-Chat
  - Utilized component to create interactive chat UI
  - Customizable attributes for sending messages, bubbles, users, typing indicator





Integration with Backend

- Utilized axios library to make requests to Flask server

- Utilized promises/callback functions to deal with asynchronous requests
  - Make sure application doesn't crash or displays incomplete information

- Backend Functionality
  - Authenticate user on login screen
  - Register user with info on register screen
  - Get user data to load data on profile screen
  - Send message on chat screen

```
const getResponse = async (message: string)=> {
  const obj = {
    message: message
  }
  axios.post(baseUrl + '/send-message', obj)
  .then((response) => {
    var responseText = response.data['RESPONSE'];
    setTyping(false)
    sendBotResponse(responseText.trim())
    console.log(response)
  }, (error) => {
    console.log(error);
  });
};
```

Backend

- The backend for the app is a Python Flask APP
- It is built using a REST API model, and servers as the layer in between the front end and the model

- The backend consists of 4 key endpoints listed below - each endpoint server to implement logic for the frontend
- Backend Calls
  - POST /send-message
  - GET /authenticate-user/<email>/<password>
  - POST /register-user
  - GET /get-user-data

Database

- Postgresql database consisting of chat information and user information

```
CREATE TABLE chat (
    user_id varchar(64),
    message varchar(1024),
    response varchar(1024)
);
```

```
CREATE TABLE users (
    user_id varchar(64),
    fname varchar(256),
    mname varchar(256),
    lname varchar(256),
    dob varchar(10),
    gender varchar(1),
    email varchar(256),
    password varchar(64)
);
```

Backend Code Walkthrough

- Code Walkthrough!

PIP Pipeline

- Data processing on Kaggle physical diseases dataset (Patil, 2020)
  - Determine unique symptoms and assign a numeric label for each unique physical illness
  - Produces dataset for symptom extraction (enumerates through combinations of 1, 2, 3, and 4 symptoms, subsampling for combinations of size 3 and 4).
    - Features: messages describing symptoms, built from pre-written message templates.
    - Data augmentation (done with 40% probability): symptom tokens reversed
    - Labels: unique symptoms (0 if not present, 1 if present)
  - Produces dataset for physical illness prediction given symptoms
    - Features: unique symptoms (0 if not present, 1 if present)
    - Labels: numeric label for physical illness corresponding to present symptoms

PIP Pipeline

- Symptom extraction
  - TF-IDF vectorization (scikit-learn developers, *sklearn.feature_extraction.text.TfidfVectorizer*, 2022)
  - Multi-output classifier (scikit-learn developers, *sklearn.multioutput.MultiOutputClassifier*, 2022).
    - Neural networks trained on dataset for symptom extraction (scikit-learn developers, *sklearn.neural_network.MLPClassifier,* 2022).
- Prediction of physical illness given symptom information
  - Random forest classifier (scikit-learn developers, *sklearn.ensemble.RandomForestClassifier*, 2022).
  - Neural network classifier (scikit-learn developers, *sklearn.neural_network.MLPClassifier,* 2022).
- Model evaluation
  - Model only trained once, validated on several different splits of the data
    - Accuracy on train/test split
    - F1 score on train/test split (scikit-learn developers, *sklearn.metrics.f1_score*, 2022)
    - K-fold cross validation (scikit-learn developers, *sklearn.model_selection.KFold*, 2022)
      - Accuracy and F1 score on each fold

PIP Pipeline

- Response building
  - Top three physical illness predictions and classification probabilities, rounded to one decimal place.
  - Corresponding precautions from physical diseases dataset, for preventing/mitigating each predicted physical illness (e.g. drink sugary drinks for hypoglycemia) (Patil, 2020).
  - Assembled into string to show the user, sent to backend, sent to frontend.

MIP Pipeline

- Data processing on emotions dataset
  - Determine most probable mental illness based on distribution of sentiment of series of user messages
  - Utilizes sklearn logistic regression model to train the classifier (scikit-learn developers, *sklearn.linear_model.LogisticRegression*, 2022)
- Predictions of most likely illness are determined by performing a time series analysis on the messages passed in by the user
  - Depression: Consistently sad or little joy/happiness
  - Bipolar Disorder: Wide fluctuations in sentiment between messages
  - Anxiety: Mix of surprise, fear, and obvious absence of strong sad/joy emotions
- Response string is built by providing the user with their most likely illness
  - Assembled in string to show to the user, then sent to backend, then frontend

MIP Heuristics

- Created heuristics to determine if patients fall into one of 4 categories: depression, anxiety, bipolar, or no mental illnesses
- For depression, checked if sentiment of sadness was the most common in a message
- For anxiety, checked if sentiment of fear was most common in a message
- For bipolar, checked if sentiments often switched from sad/fear to happy throughout a message and if these sentiments were balanced throughout
- If the patient fell into none of these categories, he/she was diagnosed with no mental illness

Research

- Datasets
  - Physical diseases dataset: *Disease Symptom Prediction* (Patil, 2020).
  - Twitter dataset: *Twitter Emotion Analysis* (Merin S, 2020).
  - Emotions dataset: *Emotions dataset for NLP* (Praveen, 2020).
- PIP Pipeline
  - Symptom extraction
    - Keyword extraction (RAKE: Rapid Automatic Keyword Extraction) (Saxena, 2020)
    - Multi-output classifiers (scikit-learn developers, *sklearn.multioutput.MultiOutputClassifier*, 2022)
- MIP Pipeline
  - Logistic Regression (sklearn developers, *sklearn.linear_model.LogisticRegression*, 2022)

Local Testing

- PIP pipeline
  - Four stages: data processing, fitting symptom extraction model (multi-output classifier of neural networks), fitting each PIP model (random forest, neural network). See command to evaluate already-trained models below.

```
$ python3 ./models/physical_illness_prediction.py --proc_data 1 --fit_se_nn 1 --fit_pip_rf 1 --fit_pip_nn 1
> ./models/physical_illness_prediction_logs.txt
```

- Response builder (for PIP pipeline)
  - Tests responses generated by PIP pipeline (14 test cases, 12 / 14 passed). See command to run test cases below.

```
$ python3 ./test.py > ./response_builder_test_logs.txt
```

- MIP pipeline
  - Stages: Data processing, Accuracy Training for LR model

```
$ python3 ./models/mental_illness_prediction.py
```

- See README.md file and corresponding log files for more details.

Solution Demonstration

- Demo time!

Future Work

- PIP Pipeline
  - Improve data processing and machine learning techniques (sentence templates, data augmentation, etc.) to improve symptom extraction.
  - Obtain more data about symptoms corresponding to illnesses, improve performance of PIP models and apply it to more symptoms and illnesses.
- MIP Pipeline
  - Improve heuristic to determine mental illness risks from sentiment analysis information
  - Support more mental illnesses beyond depression, anxiety, and bipolar disorder.
- General
  - Integration with healthcare organizations to keep providers in the loop with what the patient may be experiencing before any necessary appointments.
  - Integration with pharmacies to suggest medications that align with the precautions provided to the user by the app.

References

Merin S, S. (2020, April 17). *Twitter Emotion Analysis*. Kaggle. Retrieved March 6, 2022, from https://www.kaggle.com/shainy/twitter-emotion-analysis/data

Patil, P. (2020, May 24). *Disease Symptom Prediction*. Kaggle. Retrieved April 27, 2022, from https://www.kaggle.com/itachi9604/disease-symptom-description-dataset

Praveen. (2020, April 16). *Emotions dataset for NLP*. Kaggle. Retrieved March 6, 2022, from https://www.kaggle.com/praveengovi/emotions-dataset-for-nlp

Saxena, N. (2020, September 6). *Extracting Keyphrases from Text: RAKE and Gensim in Python*. Extracting Keyphrases from Text: RAKE and Gensim in Python | by Nikita Saxena | Towards Data Science. Retrieved April 27, 2022, from https://towardsdatascience.com/extracting-keyphrases-from-text-rake-and-gensim-in-python-eefd0fad582f

scikit-learn developers. (2022). *sklearn.ensemble.RandomForestClassifier*. sklearn.ensemble.RandomForestClassifier — scikit-learn 1.0.2 documentation. Retrieved April 27, 2022, from https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.RandomForestClassifier.html

scikit-learn developers. (2022). *sklearn.feature_extraction.text.TfidfVectorizer*. sklearn.feature_extraction.text.TfidfVectorizer — scikit-learn 1.0.2 documentation. Retrieved April 27, 2022, from https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.TfidfVectorizer.html

References

scikit-learn developers. (2022). *sklearn.linear_model.LogisticRegression* — scikit-learn 1.0.2 documentation. Retrieved April 27, 2022, from https://scikit-learn.org/stable/modules/generated/sklearn.linear_model.LogisticRegression.html

scikit-learn developers. (2022). *sklearn.metrics.f1_score*. sklearn.metrics.f1_score — scikit-learn 1.0.2 documentation. Retrieved April 27, 2022, from https://scikit-learn.org/stable/modules/generated/sklearn.metrics.f1_score.html

scikit-learn developers. (2022). *sklearn.model_selection.KFold*. sklearn.model_selection.KFold — scikit-learn 1.0.2 documentation. Retrieved April 27, 2022, from https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.KFold.html

scikit-learn developers. (2022). *sklearn.multioutput.MultiOutputClassifier*. sklearn.multioutput.MultiOutputClassifier — scikit-learn 1.0.2 documentation. Retrieved April 27, 2022, from https://scikit-learn.org/stable/modules/generated/sklearn.multioutput.MultiOutputClassifier.html

scikit-learn developers. (2022). *sklearn.neural_network.MLPClassifier*. sklearn.neural_network.MLPClassifier — scikit-learn 1.0.2 documentation. Retrieved April 27, 2022, from https://scikit-learn.org/stable/modules/generated/sklearn.neural_network.MLPClassifier.html

Thanks for Listening!