Chatbot based Behaviour Analysis for Obesity Support Platform *

Yanxin Wu[1], Ryan Donovan[1], Binh Vu[2], Felix Engel[2], Matthias Hemmje[3], and Haithem Afli[1]

[1] ADAPT Centre, Cork Institute of Technology, Cork, Ireland
[2] FTK e.V. Forschungsinstitut für Telekommunikation und Kooperation, Wandweg 3, 44149 Dortmund, Germany
[3] GLOBIT GmbH, Barsbüttel, Germany.

yanxin.wu@mycit.ie
ryan.donovan@adaptcentre.ie
binhvu@noemail.org
felix.engel@fernuni-hagen.de
matthias.hemmje@fernuni-hagen.de
Haithem.Afli@cit.ie

Abstract. The challenge created by the health problem of rising obesity rates requires novel approaches to solve. This paper presents an innovative approach in the form of a conversational platform aimed at helping users deal with with health issues associated with obesity. The chatbot platform enables collection of personal data from users to be analysed via natural language processing and behavioural analysis to provided tailored solutions for each user based on their current states and psychological traits. The gathered and analysed data is accessible. This platform developed using Microservices architecture and chatbot technology. User can interact with the chatbot to generate personal chat data stored in the platform. The collected chat data will be used for natural language processing and behaviour analysis, along with other available data, to create a customized user model. The gathered and analysed data is accessible and usable for Health Care professionals as a mechanism to encourage healthier nutrition, and the user can benefit from the platform by getting feedback and support on their methods for improving their eating and physical activity habits by way of the chatbot.

Keywords: Chatbot · Microservices · emotional states · physiological activity · Behaviour analysis.

1 Introduction

The ongoing development of mobile technology has coincided with yearly increases in smartphone and social media usage [1] [2] [3]. The user data generated from smartphone and social media use can be collected and utilised as big

* Supported by Horizon 2020 project STOP Obesity Platform.

user data-sets.Industry and research professionals have utilised such data-sets to improve the user experience of their applications or as a source of collaboration with other research parties to solve large-scale social issues, such as those seen in the public health domain.

One of the rising public health problems is Obesity. Obesity is defined here as an abnormal accumulation of body fat that is excessive, related to Body Mass Index (BMI) score greater than 30 [25]. The amount of people obese in the world has almost tripled since 1975. If this rate of increasing obesity is unabated, then almost half of the world's adult population will be overweight or obese by 2030 [5]. Obesity is not only a problem for WEIRD (Western Educated Industrialised Rich and Democratic) nations, as the percentage of people with obesity is projected to increase in 44 countries by 2015 [6]. It has proven to a problem that strikes early and remains difficult to overcome, with 80% of the adolescents suffering from obesity becoming adults suffering from obesity.

Obesity [26] has a devastating impact on public health, as it is a major risk factor for chronic diseases such as hypertension, cardiovascular, coronary heart diseases, type-2 diabetes, and certain types of cancers. Obesity is a contributor to difficult and debilitating psychological issues, as people with obesity suffer disproportional from affect disorders such as depression and anxiety [27]. It contributed to 5% of worldwide deaths in 2014. Within the EU, in most member states this problem is increasing at a rapid rate: from 2010 to 2016 the percentage of the population that is obese rose from 20.8% to 23.3% [7]. The negative impact obesity has on public health has prompted EU driven research and industry collaborations to develop innovative approaches to solve this problem.

In the market of smart health, there has been some innovative approaches developed. Some noteworthy approaches are:

- *iBitz* - An app that is aimed at children and has an active connection with a fitness tracker named *iBitz Kids Pedometer*, which tracks users footsteps and activity levels. In-app rewards are allocated to prove incentive feedback on activity levels, representing a gamification approach. The more activities the children do, the more points they gain. The points are converted result in rewards customised based on parents preferences.
- *Habitca* - An IOS and Android app. This app aids users in habit building and productivity through a gamified approach; the app allocates rewards and punishments to provide motivation for user, harnesses social networks to allow users to share their progress, and simplifies this process through a intuitive and minimal interface.
- *My Diet Coach* - This app provides a virtual coach that assists the user in their the daily diet. The app provides pictures to represent the "old" user and the "new" user in order to motivate users.

While these approaches are innovative and practical, none offer an interoperable overall support platform. Without such a platform, users are overloaded with incompatible ICT applications, making the difficult process of losing and managing weight more difficult. Additionally these applications fail to employ interoperability with state-of-the-art fitness sensoring hardware as well as cutting edge user interface paradigms (e.g. conversational chatbots). Besides this, a lot of actions exist in the market which could benefit from ICT support in many forms. This ICT support would become interoperable, if a unified platform would exist.

The paper structured as follow: section 2 detailed describe the approach of using Chatbot platform and Behaviour analysis. Section 3 shows the implementation of the platform and Behaviour analysis experiment plan. Section 4 presents the usage of the chatbot platform in the ongoing STOP project [16]. Section 5 shows some potential future work of the chatbot. Section 6 lists the support and founders.

2 Chatbot and Behaviour Analysis Approach

There is an overabundance of blanketed style approaches tackling public health problems, where the same intervention is applied across all individuals. This is despite the fact there exists large variation in the personality characteristics and emotional experiences, both of which can significantly moderate the effectiveness of public health interventions. It is essential that each person, in respect to their idiosyncratic characteristics and needs, is treated appropriately with user-driven work plans. This paper introduces a chat-bot based approach that can meaningfully and intelligently engage with platform users, extracts information about user's characteristics and needs, and enables a more personalised and more effective health intervention.

Chatbots are systems that engage in extended conversations with the goal of mimicking the unstructured conversational or 'chats' characteristic of human-human interaction. Chat-bot systems have been used for practical purposes, such as testing theories of psychological counselling [9] and E-health applications. There are several chatbot-based application in the market.

- *Youper* - Youper [18] was created by a team of scientists and doctors. The app focuses on improving user emotional health with the personalized conversation. Youper user can view the emotion record and set different goals to achieve.
- *OneRemission* - OneRemission [19] is an app aimed at cancer patients and their loved ones. "It aims at making the lives of cancer survivors, fighters, and supporters easier, safer, and more enjoyable.". The app can offer valuable information database that based on the experts' knowledge to improve user states on both physically and mentally.
- *Your.MD* - Your.MD [20] is an app base on the idea of self-care. The application can provide a big database that user can use to self-check the specific symptom.
- *Babylon* - Babylon health [21] application offers chatbot-based symptom self-check, real doc-tor video/audio check, health monitor. Babylon health company also provide real GP subscription plan.

– *Sensely* - Sensely [22] is a virtual assistant app that user can use for: symptoms checking, receiving self-care information, scheduling clinician appointment and locate the nearest pharmacies. Users have several ways to interact with the app: a chatbot associated with text-to-speech and speech recognition technologies; a virtual character system that use to improve user experience.

Traditionally, chatbots are typically rule-based. As recent as 2014, Siri and Google Now still relied on handcrafted rules to find the most relevant answers. But deep learning techniques and the availability of more user generated datasets and powerful computers have opened up new possibilities with corpus-based models. These models mine large datasets of human-human conversations, which can be done by using information retrieval (IR-based systems simply copy a human's response from a previous conversation) or by using a machine translation paradigm such as neural network sequence-to-sequence with word embeddings and attention mechanism as showed in Fig. 1, to learn to map from a user utterance to a system response [8]. There are three main components in these

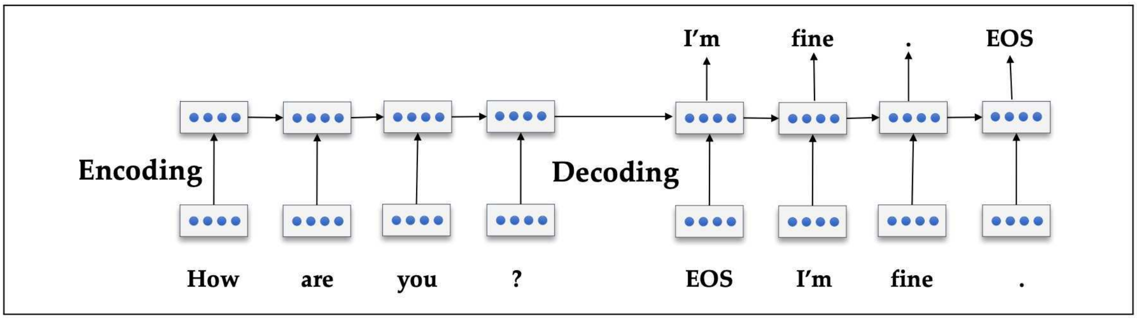

Fig. 1. A sequence to sequence model for neural response generation in dialog. [8]

models:

– *Embedding* – Embedding can be of type word or other forms of tokens such as characters or n-grams. The embedding layer is converting the input into a vector of continues numbers representing the input.
– *Encoder* – At this stage we are encoding the input embeddings (the vectors) to produce intermediate states which are fixed lengths vectors.
– *Decoder* – The decoder takes the fixed length encodings produced by the encoder and generate a variable length sentence using beam search decoding.

A number of modifications are required to adapt the basic sequence to sequence model implemented initially for Machine translation to the task of chat generation. As mentioned in [10] these models tend to produce repetitive responses like " Sorry, I can't help" or "I don't know" that can end the conversation. This problem can be technically addressed by changing the training model objective function to a mutual information objective, or by modifying a beam decoder to keep more diverse responses in the beam.

2.1 Emotions and Personality

The capability of the chat-bot to provide insights into the affective and general psychological state of its users is crucial to develop. In order to perform a feasibility study on the utility of the chatbot to enable behavioural analysis, the important psychological phenomena and their interconnections needs to be defined and clarified. This sub-section defines these psychological phenomena, their interrelation, and what signals can be used for the chatbot system to accurate detect these phenomena.

Basic Emotions This chatbot platform is intended to provide analysis of the emotional states of its users. Emotion are considered in terms of typical behavioural and physiological patterns along with the subjective experience of the particular emotion. In the context of this work, the working definition of emotion, is the subjective experiencing of that particular emotion (e.g. the typical subjective experience of Anger, Disgust, Joy, Fear, Surprise, and Sadness) coupled with physiological and behavioural activity simultaneously occurring with it. This fits the Basic Emotion Theory (BET) perspective [28].

BET state that there exists a sub-set of emotions with highly consistent and reliable behavioural and physiological patterns [13]. This consistency in basic emotion signals is culturally independent and thus makes them excellent candidates for scientific research. While there is some level of disagreement on which emotions should be considered basic, this research classifies the basic emotions as: Fear, Surprise, Sadness, Joy, Anger, and Disgust. These emotions are labelled as basic not because they are simple, but because they are deeply rooted in sub-cortical areas of the brain and are the emotions that have been the most influenced by evolution. The more cognitively mediated emotions emerge from the basic emotions (e.g. guilt is seen as a mixture of sadness and disgust). The basic emotions form the basis of all emotional experiences.

However, whilst the basic emotions have been shown to correlate consistently with physiological activity, this has not been fully investigated and been used for practical purposes. Prior research has shown that the basic emotions are associated with distinct patterns of cardiorespiratory activity [14]. For the purposes of the chatbot platform, our aim is to establish the patterns between the basic emotions and such activity, in order for our application to have another measure of assessing the emotional state of the user. This could be used in cases where ambiguity is present, such that the words people use can have a positive or negative connotation. Such information then can be used as a way to assess such ambiguous cases whilst also providing confirmation for non-ambiguous cases.

Detecting Personality Through Emotions One of the unique contributions this chatbot can provide is harnessing emotion detection in order to build a model of the user's personality. Personality is defined here as the unique way a person feels, perceives, and behaves in the world. An accurate understanding of personality enables one to understand what makes people the same, what makes people similar to others, and what makes people individually unique [29]. The value of personality analysis is in provides 'in-context' information about the person and their psychological state at any point and avoids blanket one-size-fit-approaches.

Emotions are regarded as the "prime movers" of personality [10]. How and with what intensity we experience emotions is a key component to the uniqueness of our personality [17]. For example, studies that asked participants to describe the personality of another person showed that a high number of participant's descriptors referred to the person's typical emotional experience (e.g. he/she is a happy person; he/she is an anxious person). Yet the exact nature of the relationship between emotions and personality has been difficult to ascertain due to the fact that emotion research initially faced similar challenges to personality; in that it previously relied exclusively on subjective self-report.

However, one solution to this problem has been to focus on the behavioural and physiological patterns that coincide with experience of each emotion [11]. These patterns tend to be central-nervous system (CNS) activity facial expressions, type of language and pitch of voice used, behavioural expressions, amongst others. For example, the emotion anger has been shown to have a particular CNS activity [12]; facial expressions tend to be lowered eyebrows, tightly pressed lips, and bulging of the eyes; language tends to be direct and in a higher than normal pitch; people can either be physically aggressive or display signals that suggest readiness for aggressive behaviours (e.g. clenched fist). These patterns serve as signals to the subjective experience of the emotion anger.

The identification of these components enables innovative methodologies for detecting personality that can be harnessed by this chatbot platform. Thus far, no known research has been carried investigating the links between cardiorespiratory activity and personality traits, making this a novel research endeavour. The emotions will then mediate the ability of the chatbot through behavioural (semantic) and physiological data to detect personality traits of the user, which can then be used to model particular and more productive.

However, the data sources of the platform are various, from smartphones to smart wearable devices. All the devices have their own operating system and different sensors that are used to collect the user activity data. Beside using cardiorespiratory data, other user behaviour data or sensor data also can be used to associate personality traits analysing. For example, mobile phones have internal GPS to locate the user location. Though analysing location data, some specific location will be marked. Combination of location results and cardiorespiratory data will review certain habits of the user. By using behaviour data, we can build user profiles that support analyze models. This enables behavioural analysis at a more macro-level of the person.

3 Implementation

3.1 Data Usage

Based on the requirement of the chatbot platform, data to be collected and used in this work include physical activity data collected by wearable sensors such as Fitbit wrist bands, smart watches and smart mobile phones;nutrition information provided retailors and self-reporting; physiology information, such as BMI, heart rate, blood pressures by measurement; and other self-reporting data, such as physical activities that are not recorded by sensors, feedbacks.

The physical activity data shall include types of activity (such as walking, running, swimming); duration of activity; levels of activities (such as steps, speed). These can be recorded by wearable sensors (walking steps, running speed) and self-reporting (such as dance, swimming). Nutrition information will be collected by grocery calories identification via a mobile app, meal calories estimation and self reporting.

Feedback provided to users shall be friendly, easy to understand, reliable and respect the behavioural changes on the user. A conversational Chatbot trained on behaviour analysis will be able to provide a good vehicle to achieve this goal.

3.2 Platform Implementation

When implementing this chatbot-based platform, there are several technologies been used. One is Microservice architecture(MA). Microservice architecture is a more detailed structural style than service-oriented architecture (SOA). Same as SOA, services in MA are connected through the network. However, not like services in SOA, services in MA been broken down into many micro-services. Each microservice will do a small amount of work and "group together" to perform the whole functionality of the service. By doing the broken-down process, the overall structure becomes more loosely coupled which gain more readability and maintainability.

Another technology has also been used when implementing the chatbot platform is containerization. Containerization is a technology that allows developers to wrap the application along with the specified configuration files, libraries and required dependencies together into a container which can run in any computing environment. Because a container has all the requirements needed, it will run its own without interfering with the host environment. This characteristic of the containerization makes it works well when associated with microservice architecture. There are several companies doing containerization in the industry, the one used in chatbot platform is Docker container [15]. Compare with other containers, docker containers are easier to build and more lightweight.

The benefit of using MA and docker container is that combining these two technologies will help the platform to face future challenges. Because the platform is in microservice architecture so different type of chatbot can be added at any point without stop and update the whole platform. Using containers also allow chatbot to been developed in different languages since the container can be running cross-platform.

3.3 Behaviour Analysis Plan of Action

An experimental study will be conducted. The preliminary schedule for the study is as follows:

- Step 1:Agreement on questions to be used. Finalisation of experimental materials.
- Step 2:Identification and recruitment of research participants.
- Step 3:Run Time of the Experiment.
- Step 4:Analysis of the Results.

Participants will be those who suffer from health issue. Participation in the study will be completely voluntary. Participants will be informed about the chatbot platform and the expectations of how this work can benefit those who suffer the health issue. In order to test the above, participants who suffer from

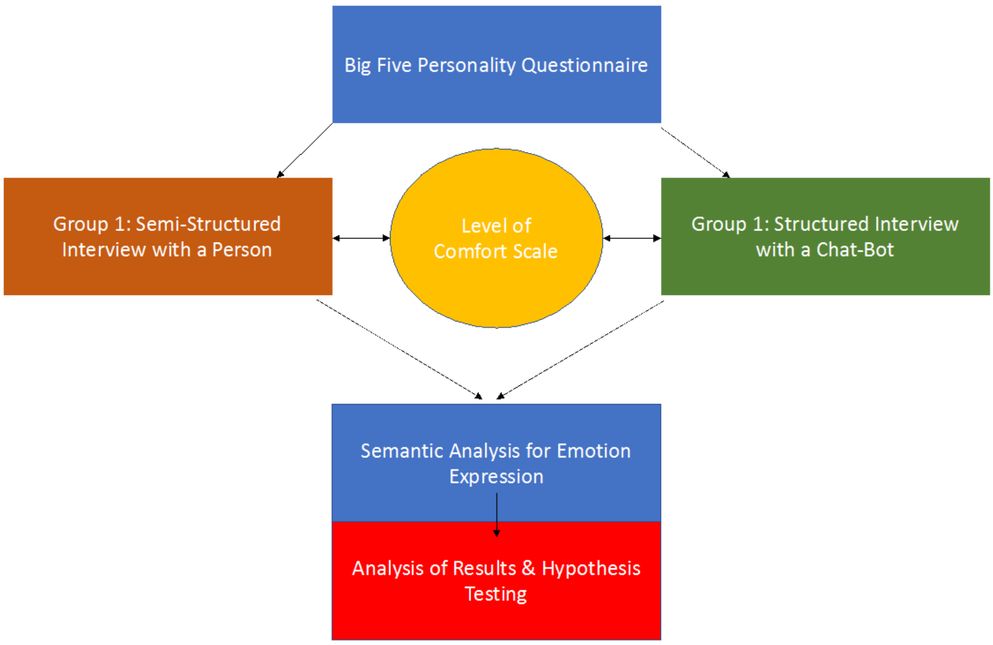

Fig. 2. Chatbot Experiment Procedure

obesity will be recruited in a two-group study. Both groups will also answer the Big Five Aspects Scale (BFAS). People will be separated into the following groups:

- One group will have participants that engage in conversation with a person using a set of questions about physical/emotional experiences.
- One group will have participants that engage in conversation with a chat-bot like app using a set of questions about physical/emotional experiences

The interview will be conducted in a semi-structured manner. The research interviewer/chat-bot will ask the participants each question at a time and follow it categorically. However, in cases where participants will have more to say on any particular topic due to their own unique life experience or opinions, then there is room for exploration into these areas and related follow up questions. The questions are therefore a guide rather than a strict manual. However, both groups will have the same set of potential questions.

3.4 User Interface Design

The design of the chatbot platform mainly includes two parts: the web front-end that users can access, the different chatbot that user can talk to. The front-end is used to access the chatbot and other functions and has two parts: the UI and the data storage. The UI is accessible for all users that allow each user to create an account to use the website(see Fig. 3and Fig. 4).

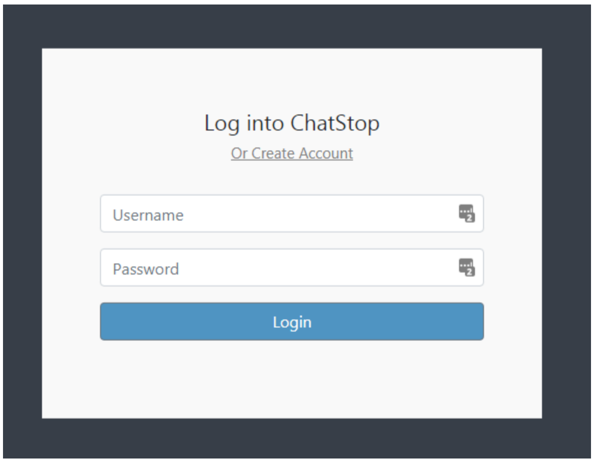

Fig. 3. Log in Page

There are two types of user for the website: Common user and Admin user. Common users are the one who will use the chatbot and can use the chatbot only. Admin user can access to more function than common user such as add new chatbots, manage existing chatbots, download conversation history from chatbots and rule management of all users(see Fig. 5).

According to the data protection policy and website management, the Admin panel option will not appear if the common user log in(see Fig. 6).

After the admin user logged in, the Admin panel can be used(see Fig. 7).

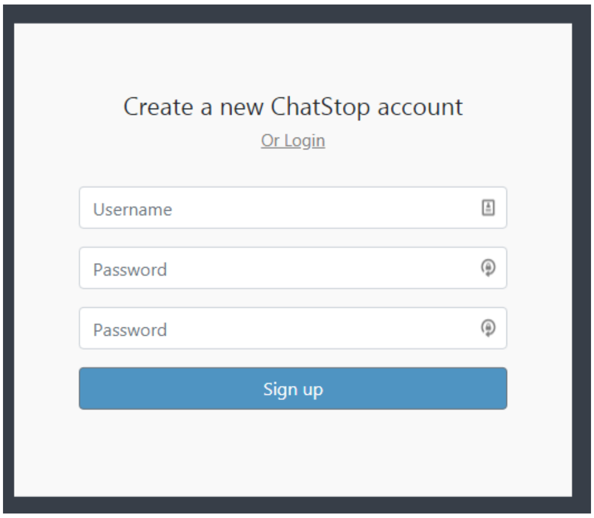

Fig. 4. Sign up Page

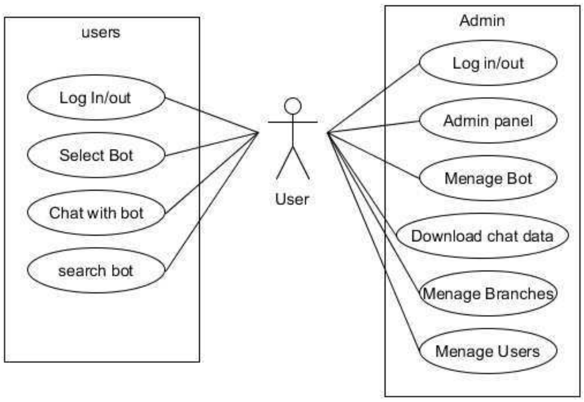

Fig. 5. User Type

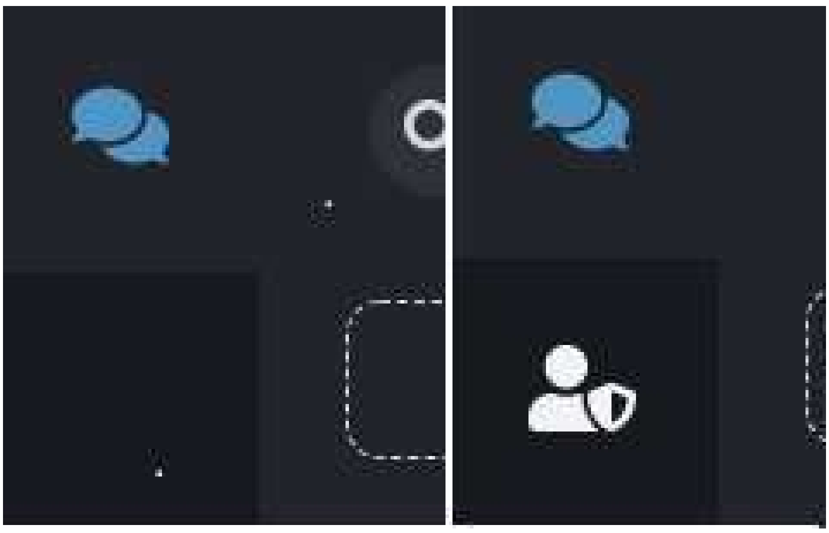

Fig. 6. Panel Option

Fig. 7. Admin Panel

The website data storage is separately deployed as one microservice of the plat-form which allows UI to connect through the specified API. All the data from the website like user information, bot information and chatbot conversation been stored in the database. The chatbot will be developed separately in different platforms. In order to add the bot to the platform, the bot will be wrapped into a docker container

4 Application

STop Obesity Platform (STOP) is a 36-months project funded by the European Union (EU). The project aims to support persons with obesity with a better nutrition under supervision of healthcare professionals. In the STOP project, user health and activities are monitored by different smart sensors and wearable devices, such as e.g. smart watch, fitness tracker. Captured data is stored, enriched, then semantically fused to enable an unified and unique data access interface. The outcome is used as inputs for sophisticated AI data analysis in the STOP Ecosystem Platform.

In STOP, the Chatbot is trained on user's physiology information, physical activity data, and nutrition information. These inputs are tailored for each user to provide a friendly, easy to understand, reliable feedback. This helps to change user behaviour toward a healthy life style with more exercises and good nutrition.

User fitness data is monitored by their smart phone and wearable devices. Data is stored on the phone by the fitness app and uploaded to the manufacture server. Depend on the manufacture, user data can be accessed by third party applications through Web APIs or Software Development Kit (SDK) for mobile apps. Based on the Wrapper-Mediator-Architecture, the STOP Ecosystem

Platform can gather user fitness data from popular services, such as e.g. Fitbit and Google Fit, and stores it in the Fitness database. Furthermore, the platform provides a REST API interface for mobile apps to submit user data.

With the REST API interface, the Chatbot can access and modify user's fitness data on their behalf.

5 Future Work

The chatbot platform is being developed in the context of STOP, an EU-funded project aims to support persons with obesity with a better nutrition under supervision of healthcare professionals [16]. In this project, each user has different fitness measures, as well as, health issues. Therefore, they need supports based on their current status. The chatbot platform, in this case, can not be trained on general input data but needs to be tailored for each individual. The outcome can be used to help each user to change their behaviour toward a healthy life style with more exercises and good nutrition. Furthermore, the chatbot can be integrated into popular messaging platforms such as e.g. Facebook Messenger and WhatsApp using their Development APIs [23] [24]. This will enable users to communicate with the chatbot anytime from their familiar apps and the chatbot to reach a larger audience on these platforms. Finally, the work of developing different type of chatbots and models to adapt the future changes in the market can also be considered.

6 Acknowledgments

This research was conducted with the financial support of the Horizon 2020 project STOP Obesity Platform under Grant Agreement No. 823978 and at the ADAPT SFI Research Centre at Cork Institute Of Technology. The ADAPT SFI Centre for Digital Media Technology is funded by Science Foundation Ireland through the SFI Research Centres Programme and is co-funded under the European Regional Development Fund (ERDF) through Grant 13/RC/2106.

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