Addressing Challenges in Promoting Healthy Lifestyles: *The AI-Chatbot Approach*

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ABSTRACT
Healthy lifestyles promotion is the main objective of primary care interventions, starting from the pediatric age, were overweight is nowadays exposing about one third of children to the risk of developing chronic diseases, such as diabetes. Recent years have seen a blast of mHealth apps for health promotion, targeting in particular nutrition and dietary behaviour change. However, reviews show difficulties in the adoption and effective usage of these applications in telemedicine and by the population in general, due to a lack of evidence-based content and strategies provided (e.g., by commercial apps) or lack of sufficient user engagement with the apps. Nutrition apps typically require self-reporting of food intake by the user which is often seen as a burden and a cause of abandonment of the app. However, current wave of research has taken up the challenge of promoting healthy lifestyles with advances in artificial intelligence (AI). This paper focus on AI chatbots as an innovative approach offering more simplicity and facilitating long-term adherence to health promotion interventions. Conversational assistants provide the advantage of being deployed in smartphones and laptops within a wide variety of applications. We will particularly focus on harnessing the power of intelligent chatbot systems to provide behaviour change interventions in telemedicine for healthy lifestyle promotion. We describe an application scenario for an AI-chatbot delivering support to nutrition education that could help to overcome current limitations of similar mHealth solutions provided for healthy lifestyles and contribute to more effective public health interventions in this application domain.

Categories and Subject Descriptors
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors.

Keywords: Behaviour change interventions, nutrition education, chatbots, health promotion, sustainability.

1. INTRODUCTION
Today there is an increasing awareness in public health that preventing unhealthy lifestyles in the population, from the pediatric to adult life, can bring enormous advantages in reducing the occurrence of risk conditions, such as obesity that leads to chronic diseases (e.g., diabetes) which represents a burden for healthcare system worldwide [1]. Recent years have seen an increasing offer of mHealth applications providing nutrition education as well as promoting healthy diet and physical activity. However, recent reviews show that most apps fail to sustain long-term users adherence, often due to a lack of evidence-based strategies and quality of the information provided [2-3-4]. Messaging platforms, such as Facebook messenger, WeChat, and WhatsApp are quite popular and users tend to spend more time chatting than using other applications [5]. With the introduction of services, like Siri and Google Now or Google Allo people are getting used to interacting with applications designed to support smart coaching. Recently, Facebook launched their chatbot platform to host businesses and provide services to customers directly from their platform through a simple conversation. The idea of "assistant-as-app" is to create user-virtual assistant interaction with either voice or natural text messaging to accomplish increasingly complex tasks with minimal effort.

Notwithstanding, the increasing number of chatbot solutions built for health and lifestyle are still amateu r and need improvement with respect to supporting complex behaviours, such as healthy dietary adherence. To this extend, the existing solutions mainly targeted food recommendation and physical activity tracking. The majority of the approaches are focused on rule-based architectures, where the chatbot intelligence is pre-defined and for each user action, the bot triggers a response from a predefined list of answers. Moreover, a few approaches have focused on combining various profiling factors and techniques to achieve a sustainable health plan. These factors are related to, for example, user personality and providing a personalised plan that fits with their preferences. In addition, sentiment analysis and user emotional condition are important factors to consider to improve the effectiveness and quality of user experience with the chatbot. Integrating the chatbot design with appropriate behaviour change strategies and techniques (BCTs) can help to effectively deploy these solutions to support behavioural interventions for healthy lifestyles and prevention by healthcare providers.

In this paper, we propose a chatbot system to promote healthy and sustainable eating behaviour as a possible application scenario for supporting primary care interventions to prevent weight gain in the adult population. The bot acts as a bi-directional channel leading to the adoption of more healthy habits regarding diet, physical activity as well as food purchasing and preparation. The presented system is unique in the way it collects data about user's relevant practices to provide personalised recommendation that fits with their preferences and profiles. Moreover, since eating behaviours and practices are strongly correlated with user's emotional and choice dynamics, the bot collects data to determine user intent and perform sentiment analysis, to provide a more tailored coaching towards a sustainable healthy diet. Finally, our approach is meant to support behavioural interventions following

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the ‘Efficiency Model of Support’ [6] where virtual and human coaching are combined to facilitate users’ transition to healthier lifestyles in the most efficient way.

2. AI-CHATBOT ARCHITECTURE FOR HEALTHY LIFESTYLE PROMOTION

Current research shows that most chatbot systems are used to access information or communicate simple instructions to the audience. A few studies have addressed the challenge of adapting conversational interfaces to detect user sentiment and interpret their intention. The existing studies on chatbot systems for diet and lifestyle are either providing a way to track meals or provide recommendation [7]. There is still room to improve these systems with respect to bot effectiveness and user’s needs. In this work, we propose a chatbot architecture that combines advanced feature integration (e.g., machine learning models) to collect and understand various features about the users. In this way, the bot can be trained to understand the user state with respect to a given plan and trigger the right action that can better fit with their preferences. Moreover, the bot is able to trigger and notify a healthcare expert (e.g., nutritionist) to facilitate intervention whenever relevant. The healthcare expert can track user activities through a web application.

The envisioned chatbot will combine multiple technical and behavioural aspects to provide the necessary intelligence while interacting with the user. These technologies include: the anatomy and finite state machine for the bot design, the framework to provide rule-based reasoning for the bot, the approach for sentiment analysis, the behaviour change techniques to understand user behaviour at a certain stage, and the intent detection approach.

Chatbot System Anatomy and Finite State Machine

Chatbot System Anatomy

Conversational agents can be of type voice-enabled or text-based, and sometimes a combination of the two. Voice enabled can listen to and respond in spoken language, whereas text-based can read and respond to typed messages and requests. All conversational agents rely on a set of core underlying technologies in order to understand natural language input and human intend, and hence engage in a human-like conversational. Figure 1 below shows the key technology steps to be considered when developing conversational agents.

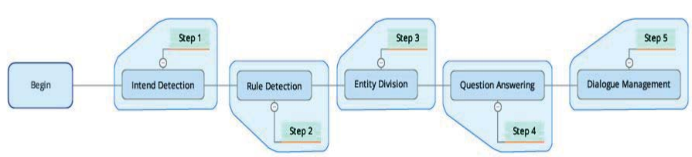

Figure 1. Conversational Agents System Anatomy.

These above steps can vary depending on the application domain. However, the order defined above better fits our chatbot scenario. The Intent Detection categorizes the request into predefined intents. The intent reflects what the user is trying to say or achieve, and hence prescribes an action that defines the desired outcome. The Role Detection assigns predefined categories to entities of particular type. For example, for the request “I had a burger for lunch”, the entity “burger” can be labeled food and the entity “lunch” can be labeled meal time. The Entity Resolution matches the identified entity with a real world object or concept. For example, resolving an entity “beef burger” into a burger. The Question Answering identifies the best answer for the request based on knowledge base or acquired data. Finally, the Dialogue Management tracks the context of the conversation and formulates the appropriate response to the user.

Chatbot System Finite State Machine

The chatbot system finite state machine refers to the number of states a user has to follow while interacting with the chatbot to accomplish the action (Figure 2, Table 1). The system follows a rule-based logic, however it relies on some APIs to add the intelligence layer on top of the system.

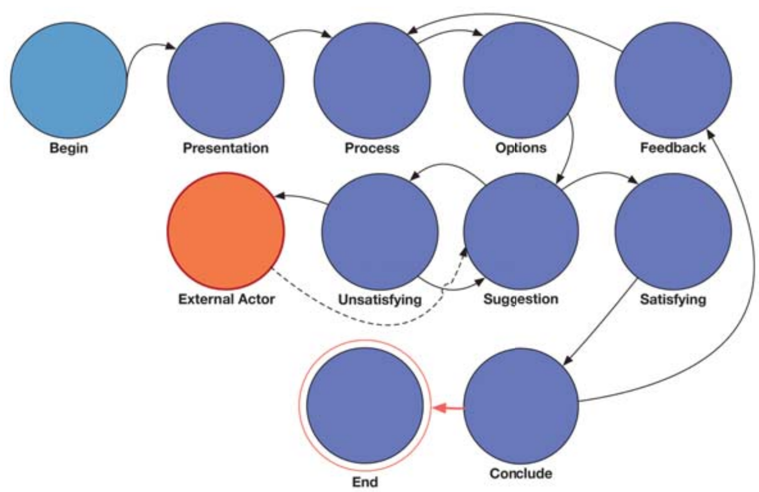

Figure 2. The Finite State Automaton for Health & Lifestyle Chatbot

STATE	DESCRIPTION
Begin	Where the conversation resides.
Presentation	Where the bot provides necessary information about the possible functionalities.
Process	The bot provides information to user based on their request
Options	The bot provides the activities for users based on their health condition (e.g., user’s daily diet or physical activity plan).
Feedback	The bot provides a feedback to the user about their performance.
Suggestion	Provides activities other than the original one.
Satisfying	When the user successfully fulfils the given activity and reaches the goal.

Unsatisfying	The system will try to provide other suggestions to the user, if one will work then it will switch to Satisfying state and conclude.
External Actor	If changing suggestion won't work, then system will request information from the External Actor state, which will involve a human actor in the process.
Conclude	Where the last goal-fulfilment task has been reached.
End	When the bot closes the operation.

Table 1. The Description for Each Finite State.

Chatbot System Architecture

The chatbot follows a rule-based logic to handle various user requests, and calls API services when providing the response to such requests. We use Microsoft Bot Framework[1] to provide a scaffolding to host message-handling logic and plumbing to integrate with various bot client endpoints. This framework simplifies the task of setting up a server process which listens for incoming text messages. Since rule-based frameworks provide no AI capabilities to parse or classify incoming messages, we will use API services, such as MonkeyLearn[2] to perform more advanced analysis (e.g., Sentiment Analysis and Intent Detection). For example, if the user types "I feel happy with the current plan", the bot can extract the mood of the user with respect to the given plan, in this case "Positive, with a certain probability", for the system architecture see Figure 3.

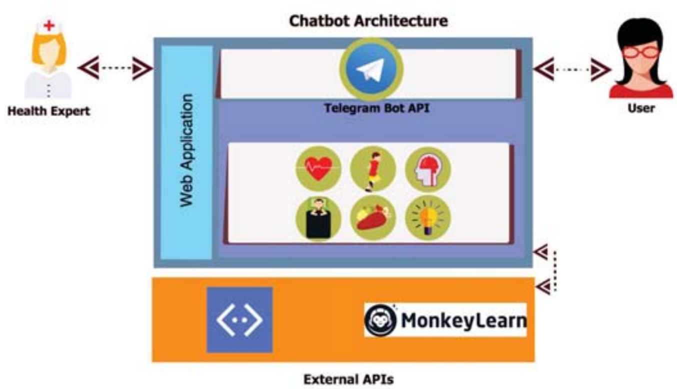

Figure 3. The Chatbot System High-Level Architecture.

Random Access Navigation (R.A.N.)

To provide as natural as possible interaction, the bot has to be intelligent enough to detect how each user asks a question. To achieve this, we followed the framework described by Shane Mac [8] to provide random navigation for the bot to detect intentions from user's requests. This model outperforms fixed decision trees and can complete more complex tasks while reduce friction [8]. The idea with this model is to detect all parameters required to perform an intent with a context, allowing the user to change their mind without going back, and it works seamlessly with web views. In Figure 4 we provide an illustration of how an R.A.N model behaves.

Figure 4. The Random Access Navigation Model.

An example of how such model works is provided below regarding a user's checking for grocery stores nearby:

• *I want to go grocery shopping this afternoon in Trento.*

• *What grocery stores are there in Trento on Friday?*

• *Show me grocery shops in Trento.*

3. BEHAVIORAL INTERVENTION TECHNOLOGIES

Within the eHealth and mHealth fields there is a subset of technologies specifically designed to deliver behavior change support to improve users' health, and they are called behavioral intervention technologies (BITs) [9]. Human support has been integrated into BITs in different ways (text messaging, email, phone calls provided by supporters with varying expertise including therapists, nurses, trainees etc.). Integrating human support, however, requires developed models for providing this assistance. The Efficiency Model of Support [6] has been proposed as a framework to guide the actions of supporters delivering BITs by helping them to effectively manage the interplay between information and intervention. Efficiency is defined as the ratio of the outcome of an intervention relative to the human resources required to deliver it, since each decision corresponds to supporting that intervention (what, when, how much, who provides it) represents a trade-off between devoting additional resources and accruing additional benefits. According to the model, decisions should be based in the consideration of why people may fail to benefit from BITs and five categories of possible failure points are proposed: usability, engagement, fit, knowledge and implementation. These points should be taken into consideration as important targets for support.

In the case of a telemedicine intervention for nutrition education the deployment of a chatbot may lower usability barriers for users, since conversational agents are considered among the most intuitive to use kinds of BITs, requiring less learning effort by the user. A chatbot would also effectively support engagement of the user by prompting and providing healthy recommendations at the time and place when food choices are made (e.g., before/during daily meals, when cooking or shopping for food). By helping users to unobtrusively keeping track of their food intake over the week the chatbot can be an ideal solution to help them acquire an accurate knowledge of healthy nutrition guidelines and to turn this knowledge into healthy habits and practices of daily life. The user-chatbot interaction may also provide an opportunity to easily collect data on user difficulties by following the behavioural intervention so as to inform healthcare provider (e.g., nutritionist, pediatricians etc.) about these difficulties and focusing the

[1] https://dev.botframework.com/

[2] http://monkeylearn.com

discussion on the critical points of the intervention for the patient, thus better personalizing and improving the efficiency of the support provided.

Chatbots can offer a lot of benefits in the telemedicine domain both for healthcare providers and patients. For example, by using chatbots patients' data logging and assistance can be more engaging [9]. Conversational agents are effective in making healthcare topics easier to understand (e.g., physical activity promotion, hospital discharge instruction, explanation of medical documents, and family health history-tracking). Bots are effective in providing nutrition education and primary care services can harness the simplicity and age friendliness offered by bots in various health interventions.

The kind of chatbot proposed for this application scenario can achieve scalability and user engagement with simple message exchange. We sum up the envisaged support provided to a user below:

- Achieve healthy eating habits: By exchanging text messages with the bot, user can receive immediate actionable feedback to improve eating habits.
- Be more active: The bot tracks user activities and helps to acquire healthy habits.
- Maintain healthy habits: By providing automation and coach support, the chatbot can teach users how to stick to their new habits over time.
- Personalised support: The bot can check the user adherence and encourage relevant activities that fit with their personal plan.
- Track user sentiment: The bot can collect emotional data about users to understand their mental/mood condition at a certain stage during their behavior change process.

Use Case Scenario

To better present the way a chatbot support may fit into a telemedicine domain, we provide a use case scenario of the user-chatbot interaction aimed at improving the user's nutrition and at implementing more sustainable food choices.

"Sara is 35 years old, she is living and working in Trento- Italy. She is busy throughout the week days and has no idea where to get veggies from the closest grocery shop. Moreover, she doesn't like to go to city often. Lately, she started having inactive life due to her job condition and as a result she put on weight. Sometimes, this condition and her work put her in a lot of stress which affects her overall life and daily dietary habits.

Sara decides to change this, she consults with our chatbot and starts using the chatbot application by simply searching the name of the bot. Initially, the bot asks some questions about Sara's preferences and other diet and health related information. Later, the bot starts to suggest support and recommendations, such as KM0 grocery shops and optimal diet that goes well with her condition and preferences. Later, the bot collects data about her compliance with the suggestions and about her feeling. All these data are communicated to the healthcare expert who can provide alternative plans or intervene with Sara whenever needed. Sara is better able to keep track of her meals and exercise by interacting regularly with the bot.

The bot analyses her meals and activity, and then sets goal and checks in periodically to keep her on track. Moreover, Sara provides information to the bot about her breakfast, and the bot explains the healthiness of her meals; by recording information about her activity, the bot is able to create an updated picture of Sara's condition and feed her with proper support."

4. Design Challenges

There are still several challenges in applying the described chatbot approach to support BITs in telemedicine. The conversations supported between chatbot and user generally cannot be very complex and they require increasing resources when expanding the chatbot domain focus. This issue might be partially overcome by future developments in the architectural design of conversational agents. Some limitations in the interaction with the bot are also due to the the singular and plural conversational forms management. For example, if we want the bot to extract entities, such as "pizza", we need to provide the plural form as well, "pizzas". The synonyms, hypernyms and hyponyms which are Natural Language Processing and ontology challenges are among the complex limitations that most chatbots suffer today. For example, if the user reports soda as a beverage, but the chatbot only knows specific terms such as coca-cola or pepsi, that are hyponyms of soda, then it can't provide a sound reply to the user request [11]. Other challenges are related to the privacy and security of the data collected, since when relying on APIs to perform sentiment analysis and tracking user habits, it's important to secure the user data collected.

Chatbots cannot replace humans [12 -13-14], but they can provide an interesting channel to deliver behavioral interventions combined to human support. The kinds of information collected and provided by the chatbot can effectively complement the support delivered by telemedicine services. This is likely to increase the quality and efficiency of healthcare resources deployed. Effective mechanisms enabling fallback in case the bot is not able to properly manage a certain situation are to be designed to facilitate human expert intervention. Future research will need to tackle these challenges by means of empirical testing in the field of these solutions.

5. CONCLUSION

The biggest advantages of chatbots include being able to reach a broad audience on messenger apps, as well as the ability to automate personalised messages. They can also improve efficiency of resource allocation in the healthcare domain by offloading clinicians and human operators from tasks that can be automated.

Chatbots represent an innovative approach to address challenges in the telecare and prevention domains. If well-designed and implemented, chatbots can increase users' engagement and self-empowerment, by providing a better experience and save costs for the healthcare system. However, designing an intelligent chatbot that responds well to user demands is not trivial. The chatbot ecosystem is moving very fast and new features are being released every day by the numerous existing platforms. In this paper we discussed an application scenario regarding a chatbot system to promote healthy nutrition. The system adapts machine learning techniques provided by API services to improve the bot intelligence. We proposed a chatbot approach over mHealth alternative solutions because it can fit well with usability requirements that are essential for supporting interaction by different target user groups. The bot provides a large set of relevant functionalities ranging from food recommendation to help shopping in a sustainable way. The fact that tech giants like Google, Facebook, Microsoft, IBM and Amazon are giving increasing attention to chatbot solutions is a strong indicator that this technology will play a key role in the future. Currently, there is an incredible amount of platforms and tools providing different complexity levels, expressive powers and integration capabilities. Which one to choose depends on the contextual design and application scenario considered. Future work is still needed to advance the Artificial Intelligence techniques required to obtain intelligent chatbot solutions for the healthcare domain, especially in terms of machine learning components, sentiment analysis and intent detection.

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