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Making Space a better Place: Just In Time Adaptive Interventions for Healthy Lifestyles

Arend Ligtenberg[1], Monique Simons[2], Marjolein Barhorst[2], Laura Winkens[2]

[1] Laboratory of Geo-Information and Remote Sensing, Wageningen University and Research, the Netherlands
[2] Consumption and Healthy Lifestyles Chair group, Wageningen University and Research, the Netherlands

Correspondence: Arend Ligtenberg (arend.ligtenberg@wur.nl)

Abstract.

Just In Time Adaptive Interventions (JITAI) are a class of applications that provide tailored support at the right time and place to help people to maintain a healthy lifestyle. This paper presents the initial version of a JITAI application that helps users to make healthy food choices when walking in an urban environment. The app provides interventions based on location, time, and user characteristics. It adapts its interventions based on the type and goal of a user. The JITAI consist of an app for a mobile phone and a backend server. Using the backend, decision points and interventions can be managed as well as users. Moreover, it stores tracks and intervention data. A two-phased experiment will be set-up. The first phase will test the robustness and functionality of the application with a limited number of users. Based on this, the app will be adapted. The second phase will test the effectiveness of the different type of interventions by involving a large user group.

Keywords. JITAI, LBS, movement analyses, healthy lifestyle.

1 Introduction

Just In Time Adaptive Interventions (JITAI) are a class of M-Health applications designed to provide tailored support at the right time and right place (Nahum-Shani, Smith et al. 2017, Wang and Miller 2020). Most JITAI use mobile technologies such as smartphones and sensors to detect when a person is vulnerable and susceptible for support. Applications of JITAI are found in the reduction of sedentary behaviour (van Dantzig, Geleijnse et al. 2013, Thomas and Bond 2015, Müller, Blandford et al. 2017), additive behaviours (Gustafson, McTavish et al. 2014, Goldstein, Evans et al. 2017), or psychological diseases (Ben-Zeev, Brenner et al. 2014).

This research describes a work in progress of a JITAI application that supports better food choice for a general public. A sub-optimal diet was found to be an important risk factor for disability-adjusted life years and deaths worldwide (WHO 2021). Many people face difficulties when adopting and maintaining a healthy lifestyle. The modern foodscapes found in many cities make it extremely difficult for people to make healthy choices (Wilkins 2005). Currently many countries in the world are facing an obesity pandemic and unhealthy diets are related to an increased prevalence of chronic diseases (WHO 2021). From research it became clear that health behaviours such as eating behaviour vary from day to day depending on intra individual, inter individual, and environmental factors (Chevance, Perski et al. 2020). The just in time and adaptive capabilities of the JITAI concept are expected to provide a positive contribution to the necessary change in behaviour when pursuing a healthier lifestyle.

Until now only few JITAI applications target on eating behaviour in the public space such as city centres, shopping malls or train stations. Unclear is how the spatial environment might affect food choice of people and how effective interventions are.

From a geo-information science perspective JITAI falls within the class of Location Based Services (LBS) (Huang, Gartner et al. 2018). An example of an LBS application is found in the work of the MOTIVATE system: a spatially enabled recommender system for promoting a healthy and active lifestyle (Lin, Jessurun et

al. 2011). Other applications are found in remote health monitoring for elderly (Huang, Gartner et al. 2018)

2 Methodology

The proposed JITAI application serves three purposes. The first is to provide interventions at the right time and place, such that it stimulates a sustainable behavioural change when it comes to choosing food when moving around in public space. The second is to analyse the effects of the spatial environment on the behaviour of people. It is expected that the type and distribution in space of the diverse food outlets and shops as well as the function and design of the (urban) environment influences the choices made by people. The third goal is to analyse change in movement patterns as a measure for behavioural change. Interventions are likely to affect movements of people, reflected in for example change in stop and go patterns or route choices.

For a JITAI application to be effective it is important to provide interventions only when people are receptive and vulnerable, hence the just in time aspect. Moreover, the system should be able to adapt itself to the specific behaviour and preferences of the user. Therefore, the JITAI application should be able to identify risk factors relevant to a particular user.

For the JITAI presented in this paper the risk factors are mainly determined by the combination of location and time. Being somewhere at a certain time or during a certain period influences the susceptibility and vulnerability. Based on the time and location as well as on personal goals such as "losing weight", "eating healthier" etc. specific interventions might be issued.

More formally interventions are generated by decision rules that are fired depending on decision points, intervention options, and tailoring variables (Trujillo, Senette et al. 2018) (see Fig. 1)

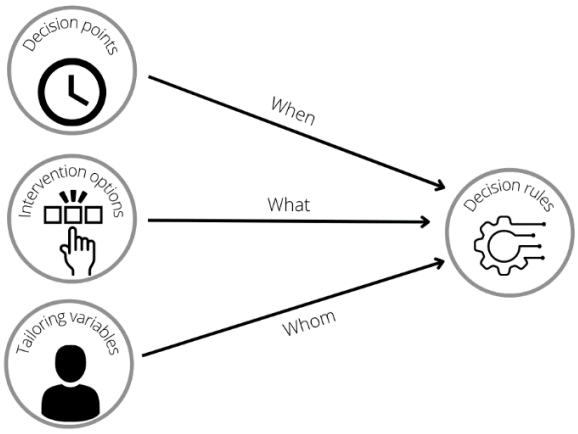

Figure 1: Concept of JITAI after (Trujillo, Senette et al. 2018)

Decision points

Decision points are defined here as spatial temporal points. During a certain period, a geographic location might trigger an intervention. The place and time of the intervention depends on the characteristics of the user, and the goal of the user. At this moment the Spatial Temporal (ST) characteristics of the decision points are static i.e. they do not respond to feedback of the users. In future version the ST characteristics will be made dynamic by implementing a machine learning approach such as reinforcement learning. Decision points can be defined individually or can be part of a 'franchise'. In case of a franchise, each belonging decision point shares the same interventions. This makes it easier to create collections of decision points having the same characteristics. A decision point can be 'active' continuously or only at certain days, dates, periods and/or time. Each decision point can have one or more interventions attached to it.

Interventions

Interventions can be defined as a question (either (multiple/single choice, or open), a command or a suggestion/tip. The interventions might differ for the same decision point depending on tailoring variables. Interventions are only triggered when a user stays longer than a predefined period within a predefined radius of an intervention point. The various intervention types facilitate different the types of support a user need at a certain time and place (instrumental or emotional) (Trujillo, Senette et al. 2018). An intervention can be triggered continuously or only at a predefined period, days, and time. Interventions are coupled to one or more goals.

Tailoring variables

Tailoring variable are those variables that characterise a user such that interventions can be adapted to optimally connects to what a user needs and want. These variables include relative static data such as personal data like gender, age, weight etc. but also data about the specific goals a user wants to pursue. Another type of tailoring variable concerns the more dynamic characteristics that is generated base on the actual behaviour of the users. The JITAI system might for example record interventions that are successful and use this information to adapt the decision rules that fire interventions. The current version presented here only implements static tailoring variables.

Decision Rules

Decision rules generate a specific intervention that is adapted to the need of a user based on the decision point characteristics, the tailoring variables and the available interventions. This can also be a non-intervention for example when a user already received several interventions and his/her susceptibility lowered or when a user is not vulnerable. A decision engine integrates the

various data from the decision points, tailoring variables and available interventions. As such the decision rule might change over time when adapting to specific users' responses.

Intervention Area

The JTAI app is only activated inside an intervention area. An intervention are is a spatial extend where the app is active and interventions can be send. Decision points always are inside an intervention area. Once inside the intervention area, users are tracked by storing a ST recording every 5 seconds. Also activated interventions and responses to interventions are recorded.

3 Analyses

To test the effect of the adaptive interventions on the proximal behaviour of the users both the detailed tracking data and the reactions on interventions are stored on a server. This enables the reconstruction of the movement patterns. By analysing the movement patterns and by combining them with responses on the interventions it is possible to explore the effect the different interventions have on different user groups. Change in routes and reside times at decision-points can be an indicator of the effect of an intervention. Moreover, it can be verified if interventions are followed-up as also the user reactions to the interventions are recorded. Although the locations of users are recorded every 5 seconds it is unclear if the GPS accuracy of common mobile phones is sufficient to detect the subtilities in the movements patterns. Especially for situations where urban canyoning occur it might very well be that the signal-noise ratio of the GPS location is too high.

A two staged experiment will be set-up. At the first stage the functionality of the app will be tested. The reaction of people to different interventions and the analyses techniques for the movement analyses will be further developed. This study period is two weeks. For the first week, participants are asked to install and activate the app, but no interventions will be prompted. In the second week participants are asked to use the app intensively and answer all the questions they are prompted. Prompts and questions are sent based on their location and the time of day. Data is collected when the participants are in the research area (e.g., Wageningen) and their mobile phone is on. Participants do not have to alter their normal behaviour.

After the first stage the app will be rolled-out in a larger experiment to test the interventions and the change in behaviour. Target groups at this stage will be mainly people living in neighbourhoods with a lower social economic status as they appeared to be more vulnerable.

4 Implementation

The JITAI system consist of a backend and an Android app. The backend system is used to define intervention areas, decision points, interventions, goals, and users. Figure 2 provides a screenshot of the administrative backend. Using the backend the tracks and responses on interventions can be downloaded for further analyses.

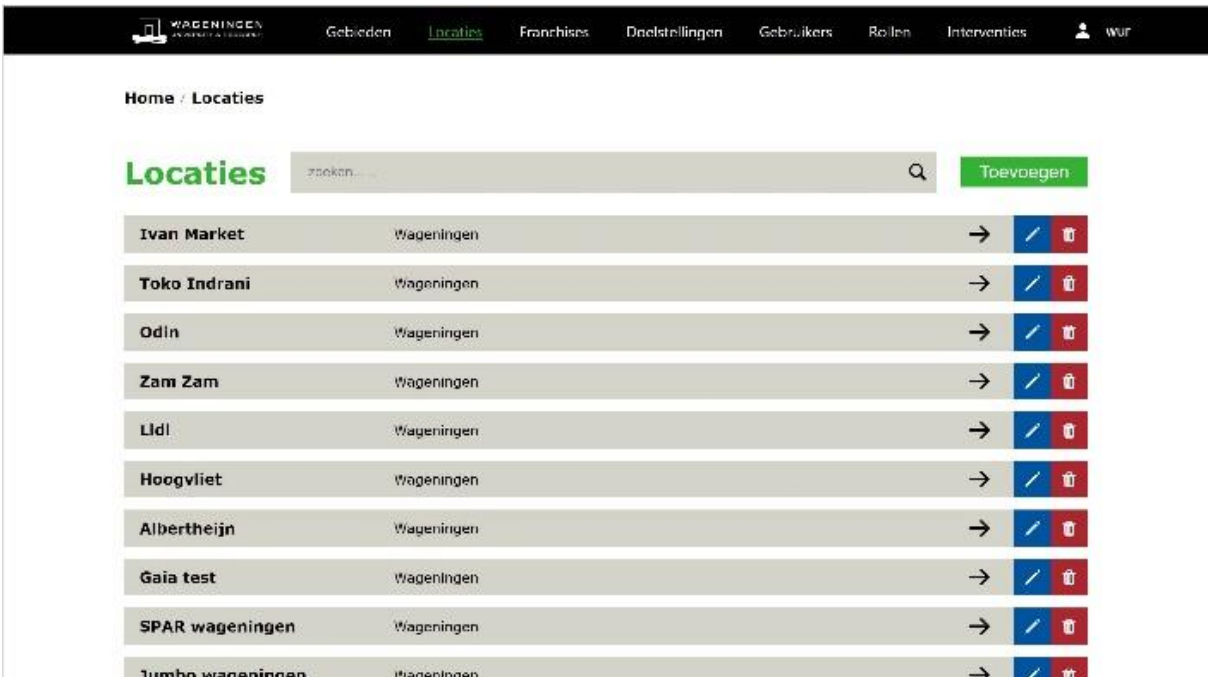

Figure 2: the JITAI backend

The JITAI app is developed using Flutter. Figure 3 shows the notification area and an example of some interventions questions. Currently the app is in its testing phase. Crucial for a proper functioning is a reliable recording of the

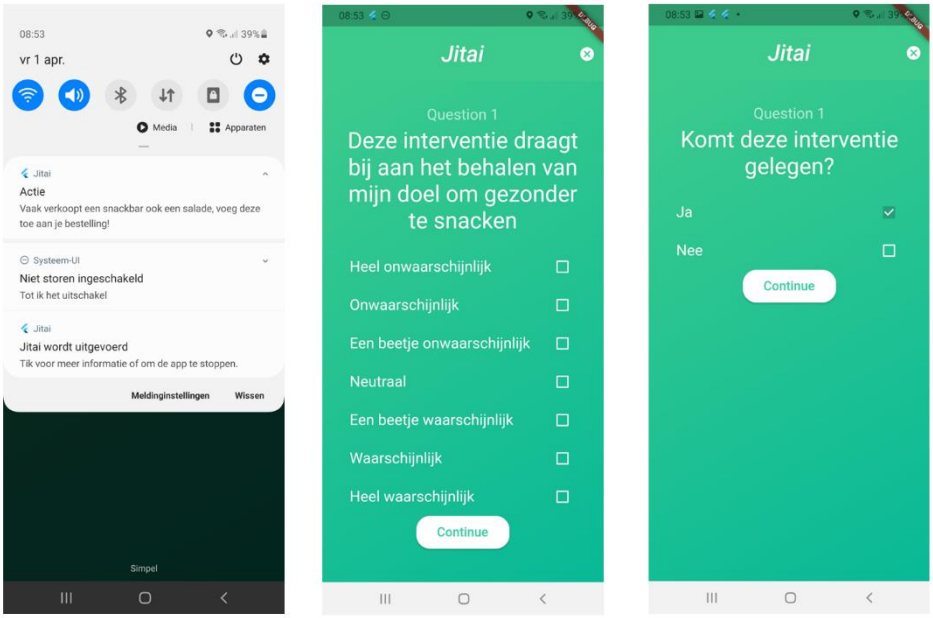

Figure 3: Screenshot of the JITAI app

tracks and responses to the interventions. The app will therefore send its data incrementally to a server after each intervention. Tracking is a continues process. To ensure the privacy users of the app can define a 'save area' where they are not being tracked.

Discussion

This paper presents a work in progress. It concentrates on the development of a JITAI application and identifying appropriate analyses techniques. A backend and an app are developed and constantly improved. A pilot test will be performed to see which elements contribute to the performance of the JITAI application, to improve the application for the next stage of testing. In the geo-science community lot of experience has been gained in developing LBS applications and crowd sourced data collection. Additionally spatial association techniques such a LISA can be used to analyses movement patterns as demonstrated by (Orellana 2012). However it is still not clear if the collected tracking data can identify the, often-subtle, effects of interventions on the movements of people. Distortions in the GPS location caused by device that are stored in pockets and bags or urban canyoning effects might introduce a serious amount of 'noise'.

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