Project proposal for MSc Embedded Systems

TU Delft – Interactive Intelligence

User valued smart reminders: Finding Appropriate Moments for Support in Socially Adaptive Electronic Partners

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# Synopsis

This project will focus on finding what defines an appropriate moment in regards to providing support through a Social Adaptive Electronic Partner (SAEP). It paves the way to ultimately answering the question “Given a user’s daily activity, what is considered an appropriate time for support feed-back, taking into consideration the user’s norms and values, to achieve a certain goal?”.

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# 1 Project fundamentals

## Introduction

The use of technology to support the daily lives of people is an ever-prevalent topic. Through applications in smart homes, wearables, virtual coaches and many others, we can improve our health, efficiency and be more connected. Conversely, the abundance of apps and notifications causes us to grow immune to the constant stream of information that is presented to us in a daily basis [1]. Especially the elderly or people with a mental impairment could benefit from an effective support agent [2]–[7]. In order to create a truly effective support agent, it is crucial to not only generate feedback in relation to the user’s actions but to provide this feedback at an appropriate time.

But what actually is an appropriate time? The appropriate time for feedback is inherently linked to the nature of the user’s action. To illustrate this, consider the following examples.

1. An elderly lady, Joanna, forgets to call an important client during the day. She wants to be reminded the next day at work.
2. An elderly gentleman, Peter, forgets to take his medicine. Since he has high blood pressure, timely consumption is of importance.

In the first example, a simple reminder notification will suffice. A naïve solution would be to use a simple alarm or reminder app in which she sets a time that is deemed appropriate. However, what happens if the next day, that time is no longer appropriate because, for example, a meeting is planned. Most likely, she will read and immediately ignore the message, forgetting about it once again because at that moment, the meeting is more important to her. Ideally, her phone would analyze her schedule and remind her outside of meetings and before the end the day.

In the second example, prompt notification is of the essence. Not taking the medicine in time severely demotes health; a value which Peter probably values greatly. As such, almost any action should be interrupted for this. However, the intake of medicine is also very predictable. So rather than interrupting any activity, the moment should be preempted and any interruptions should be avoided.

Identifying such an appropriate time for support feedback for a specific scenario is not difficult. The difficulty of this lies in the generalization. While the above examples can be implemented relatively easy at design time, diversions from normal behavior are not handled. Existing technologies are often made by hardwiring norms and as such are very rigid and unable to adapt to evolving norms [8]. Furthermore, dealing with different problems, such as remembering to turn on the alarm system before leaving work, would require a completely different implementation. Nonetheless, generalization requires analysis of goals and the values underlying the user’s daily activities.

## Problem description

The problem of finding boils down to a few steps; each worth further analysis in their own right. For now, an even simpler problem is considered, not forgetting your keys.

Working our way back, the first question that arises is what defines the goal. The goal is defined by the users and can be anything such as: *“I want have my keys with me when I leave home”.* Assuming we know the user’s activities of daily living (ADL), and consequently the location of the keys at any moment, the first step is analyzing which prerequisites there are to attaining that goal. Usually, a goal is not an independent action taken, but rather the consequence of a series of actions. As such, knowledge is required on how a goal be deconstructed into a number of distinct prerequisites.

In order to analyze arriving at this goal, some sort of model needs to be created from the user’s ADL. Once this model has been created, we can use it to analyze the limits of the possible moments for support. More directly, the prerequisites will indicate a number of actions that will have to have been completed, but also some actions may not have been completed. For example, a user will first have to arrive home, but should have received the support feedback before leaving once again, when the user will need their keys. However, Finding the most suitable moment for support is dependent on more than just this.

Finding the most “appropriate” time for the support feedback boils down to finding a moment which is both maximally effective and minimally invasive. For example, sounding an alarm in the middle of a person’s sleep may be very effective, but it sure is annoying. The problem is, however, that it’s difficult to quantify invasiveness.

Summarizing, the required steps are:

* Definition of the goal and its prerequisites
* Analysis and modelling of the user’s ADL
* Analysis of effectivity
* Analysis of invasiveness

## State of the art

The concept of a Socially Adaptive Electronic Partner (SAEP) has been previously introduced by van Riemsdijk [8]. It follows the ideology that technology should adapt to the user and not vice versa. As such, its logic incorporates the norms and values of the social context. Subsequent work has been done expanding on this, including temporal logic and analyzing actions and habits. [9]–[11].

### Existing implementations

More and more apps are taking advantage of the increased use of smart devices and services in order to get a more accurate picture of the user’s ADL. Examples include:

Olisto/IFTTT [12], [13] Can combine date, location and smart device information to, for example, give reminders when leaving home and a specific power consumption is still high (i.e. the TV is still on) and subsequently turn it off.

Maps/Waze [14]–[16] Combines real-time traffic information and address in calendar events to provide timely departure reminders.

Timeful [17] Combines user activity, calendar and to-do items to estimate duration of to-do items, plan them in and generate reminders at off-peak times.

While very promising implementations, most apps predominantly rely on design time logic. Exceptions to this usually create a predictive model and verify this with the user in order to strengthen the model [17], [18].

### Prior research

There have been various approaches as to how and when to provide feedback to the user. Generally, the preferred method of feedback is “smart reminders” [19]. Similar to the implementations, papers frequently focus on finding novel ways of combining information from smart devices into producing reminders, following norms provided at design time. Examples include combinations of location and time [20]–[22], events based on smart devices [3], [23], [24], or a combination of numerous sources of information [25]–[27].

The more innovative ideas add an extra logic layer on top of the data of the user’s ADL. Analyzing the user’s values is an intrinsic part of establishing a model. A simple but tedious approach is to ask for user feedback whenever values are needed. Instead, Zhou et al. [28] use a fuzzy linguistic approach to determine value levels.

Rather than specifying norms at design time, they are constructed based on the ADL. Several approaches are proposed. Chaminda et al. [29] suggest coupling complex activities that have a strong relationship among initiation and conclusion, such as closing the tap after opening it. Other papers [2], [30] support this analysis of temporal relationships between activities, in order to generate a set of norms for the support agent. Other context-aware approaches vary greatly. For example, Vurgun et al. [31] apply a dynamic Bayesian statistical approach. Giorgini et al. [32] use label propagation algorithms to break down goals and identify all prior actions necessary to achieve the goal.

Another approach for this makes use of Behavior Change Support Systems (BCSS) [33] by applying principles of Human Computer Interaction (HCI) [34]. This practice is used increasingly in health focused applications to make sense of the abundance of data. Examples of applications [35], [36] share large similarities with the analysis of the user’s norms and values.

## Research description

As previously mentioned, there are several steps in finding an appropriate time for supportive feedback. However, time is limited and several aspects have already been researched plenty. As such, let us limit the focus of the thesis research.

The first two steps, goal definition and ADL analysis are all linked to activity recognition and analysis to provide smart reminders. As discussed in the previous paragraph, several models covering exactly this already exist. Each having their own properties, advantages and disadvantages.

The effectiveness and invasiveness are both quite difficult to quantify. However, they can be combined into user values. These, in return, are more quantifiable. To illustrate this, let us revisit the example of the elderly man, Peter. The goal, taking his medicine in time, drastically promotes his value of health. The moment the supportive feedback is provided, however, may demote that value or another. For example, if it causes him to wake up from his sleep, it will demote his value of health, or if it interrupts him during a phone call it may demote his value of social contact.

Combining the previous matters and these realizations, the focus of this thesis will be combining the concepts of a SAEP and expanding on the existing research as discussed before. The overall research question is:

How can existing smart reminder systems be extended to incorporate user values to provide appropriately timed supportive feedback and thereby increase the user values.

The expected outcome of this question is a model which provides timed feedback based on the user’s ADL and value input.

Subsequently this leads to a number of sub-questions that need to be answered before this:

R1: What are the requirements for the smart reminder system model?

R2: Which existing models and systems exist for smart reminder systems and how do they compare.

These two questions should provide a good overview on the abilities of the existing systems and the amount of work required to extend them to incorporate user values. Of course, for this we need to be able to actually find out about the user values.

R3: What are possible ways of analyzing and quantifying the values of the user?

R4: How can the model be extended to incorporate user values?

Ultimately, all knowledge can be combined into a model which can be used to approximate the most “appropriate time” for support feedback. This model can subsequently be implemented in a piece of software in order for the model to be dynamically generated depending on new input regarding the ADL, goals, norms and values. Once such an implementation has been made, the model can be tweaked according to findings and should be tested. This brings us to the final sub-question:

R5: Does the use of the extended model improve support for user values?

This will require prior planning of possible testing methods and clearly defined testing scenarios.

# 2 Planning

## Staging

Following is a list of the stages and corresponding deliverables that act as a guideline in the planning of this master thesis. They follow from the research questions described above.

### Literature study

An extension of the preliminary research, focusing on the viability and extendibility of the approaches previously mentioned. In general, increasing the knowledge on subjects such as BCSSs, HCI, ADL analysis and other possible ways of analyzing and linking user goals, norms and values. This should compare existing implementations and analyze how we can extend them.

Product: Literature report, updated project plan  
Duration: 7 weeks

### Initial extended model design

Combining the gathered information and the principles of a SAEP into a possible structure of the extended model. Also a method of testing should be analyzed and planned accordingly.

Product: Theoretical description of model structure  
Duration: 5 weeks

### Model implementation

Creating a piece of software which can dynamically define the model based on a given ADL and the user’s input regarding their goals, norms and values.

Product: Software producing dynamic model  
Duration: 5 weeks

### Model analysis

Using the designed model to analyze and determine possible support moments. After manual analysis the model is tweaked accordingly. This is repeated to achieve a better model. The model is ultimately tested and analyzed. This testing is planned in advance.

Product: Extended software; testing; report describing the analysis  
Duration: 5 weeks

### Final reporting

All the gathered information is ultimately combined into a coherent report and an oral presentation

Product: Finished thesis report; final presentation  
Duration: 3 weeks

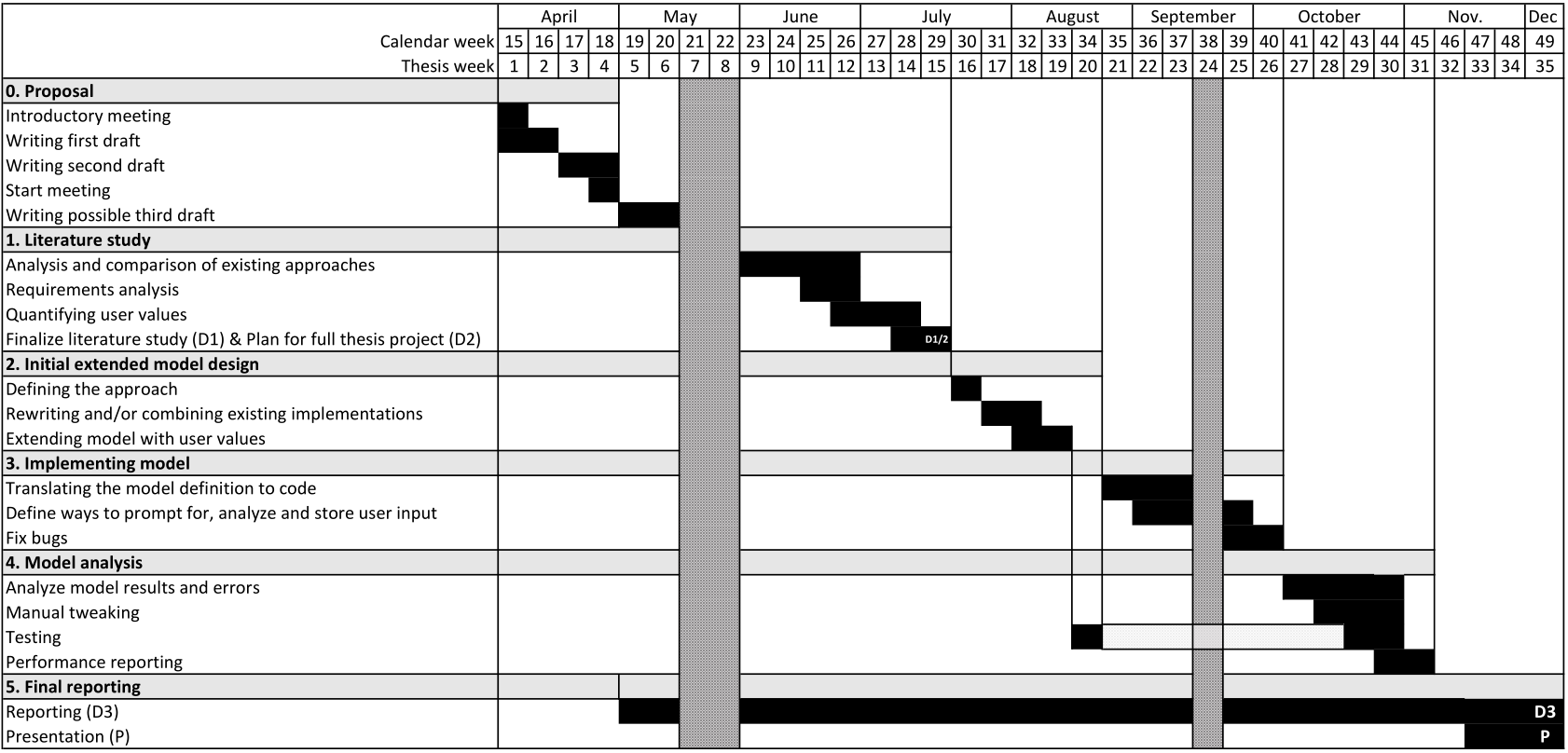
## Time planning

Taking the above stages into consideration as well as known holidays, the planning is shown in the attached Gantt chart. Note that this is a guiding planning and may be subject to change.

## Risk analysis

The biggest risks throughout this timeline are:

* Scope creep: It is easy to get lost in all possibilities which a completely generic solution might entail. It is important, however, to allow for restrictions and assumptions where necessary.
* Doubting the approach of the model: The first step is combining existing knowledge to form an approach to the model creation. There are, however, no real bad options. One may just be better than the other. It is important to trust in the performed research and stick to the chosen approach.
* Temporary intermissions due to work: For the purpose of my thesis, my contract at my work has been paused. However, due to shortage of staff and limited knowledge I may be requested to return for one or two weeks in case of emergencies.
* Temporary intermissions due to sports: Due to my pursuit in sports at high levels, I may be required to briefly halt my work for a few days to go to an international competition such as a world championship. However, the dates are often unknown until shortly beforehand. As such, they cannot be planned yet.



# 3 Personalia

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## Supervision

At the minimum, aim to maintain a bi-weekly meeting schedule with an alternating bi-weekly update via mail.

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