Sharing Green Spaces at the Umeå Academic Campus

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1 Introduction

In Umeå, the university and academic hospital are located next to each other in an area that is relatively separated from the rest of town by a few large roads. The hospital is the largest in Sweden and is still expanding. Due to this expansion, the green spaces around the hospital are disappearing. Although there are plenty of green spaces connected to the university, these are hardly used by people at the hospital, even though they are neighboring the hospital as well. The challenge is to create (cost) effective interventions that push more people to naturally start making use of these available green areas.

Umeå's municipality is interested in using agent-based simulation to experiment with different interventions before putting anything in practice. Our goal is to create a model that allows them to try out different policies for the area and observe their effects. Thanks to the availability of detailed traffic data for the area, we can design a basic simulation in which the agents' patterns of movement around the city fairly accurately mirror some of the real life patterns measured by the municipality. These transport patterns are only a part of the whole pattern of life and need to be complemented with behavior at work, study, hospital visit, etc. Since the purpose of the simulation is to test various behavior modifying strategies, the agents also require motivations (such as intentions, goals and values) for their behavior such that these motivations will generate both the traffic behavior as well as intuitively realistic other behaviors. Almost no data is available for the non-transport behavior. Therefore, the design of the agents needs to include an underlying decision architecture that can then be customized to accommodate different assumptions about their motivations and cause them to respond differently to different proposed behavior modification strategies.

To properly account for these needs, the decision architecture of the agents will require explicit representations of cognitive and social concepts. First, goals. If we want to change the behavior of some agent, we must also know what that agent is trying to achieve. Were this not the case, it would be impossible to see the effect of an intervention on an agent, since the simulation cannot construct an alternative plan for the agent. Second, once goals and plans are in place, agents need a way to prioritize them. For this we use values [11], which determine what humans consider important. If after an intervention an agent needs to make a choice between different plans, then it can use its values to decide between these plans. Values have been implement in a number of simulations, for example in [2] and [4].

Since we want to influence behavior, it is also necessary to build an explicit representation for the routine behaviors that agents can have. For our purposes, two types of routine behavior are particularly important: habits and social practices. Habits are individual repeated behaviors, which can change given the right influence [6, 14]. Humans are also social creatures, so the simulation will also have to incorporate social practices [12]. Both habits and social practices have been used in simulations for behavior change before [1, 5, 7, 8]. We are interested in these particular kinds of behavior because they govern the routines of life and are resistant to change. Unlike planned behaviors, these behaviors are mainly automatic and are not likely to change based on new information or new available actions. In order to change these behaviors different interventions are needed. On the other hand, if they could be replaced with more desirable alternatives, the changes will impact everyday life and are more likely to last, both desirable outcomes of the project.

A close cooperation with the municipality is required in order to design scenarios for testing. This brings us to the other main challenge: the municipality wants to experiment with multiple (as yet undefined) types of interventions, which means we cannot deliver a single simulation. Our approach is to build a sandbox-type platform in which policy makers can design their own simulations around the interventions they are interested in, observe the results, and adjust their approach on the fly. This, in turn, emphasizes the need for agents capable of complex reasoning because they would need to be able to cope with an unknown variety and type of interventions.

2 Starting situation

The university employs about 4000 people, and is attended by more than 30.000 students. The hospital employs over 5000 people and serves more than 10.000 patients a year [10]. All this activity takes place within an area of about one square kilometer. The existence of several little used green spaces in the midst of this area is reason to investigate whether they can be shared between university and hospital users to promote overall well-being.

The Umeå municipality keeps very detailed traffic statistics [13] broken down by means of transportation (cars, bikes, buses, by foot), purpose of travel (work, leisure, errands etc.), time and start of travel, weekday, seasons, and demographics. In addition, this data is mapped over the geo- and urban area, which is important for a spatially accurate simulation, which, in turn, lets us account for how traffic participants get around and decide where to go and which paths to take. Note that seasonal data is important, because between November and April most ground is covered by snow and cannot be used in the same way as in summer.

Data concerning the habits, social practices and short term goals of the people in the area is not as readily available. Some of this information is easy to find for some of the categories (lunch times, students' free time), but it is more difficult for patients and their families, not in the least because they are a very heterogeneous group in terms of familiarity with the area, reason for being at the hospital (and therefore state of mind and priorities), ability and means to get around etc. Any assumptions made about this kind of data will have to be carefully documented in order for the simulation results to be interpreted correctly.

3 Conceptual model

We want to support the Umeå municipality with this model. The purpose of the model is to serve as a sandbox model that contains a suitable level of complexity, but is easily adaptable. This means providing a platform on which the municipality can test different solutions and ideas they have. Based on the results, the municipality can then derive indicators on how to implement the desired behavior change.

The sandbox will be able to represent and run simulations for the following intervention types.

Knowledge modifiers Signs or posters in the hallways and outside of the buildings could be used to indicate available green spaces at the university. This can help especially with newcomers or with people passing by. Furthermore, this can also help to incorporate another group of people into the behavior change process, namely visitors of patients. Additionally, flyers can be provided at the information desk to inform people about the green spaces. The hotel on the opposite side of the hospital can also be utilized to promote available green spaces. Flyers or other sorts of advertisements could be placed there. As a result, visitors could stay near the hospital and help promoting new green spaces through usage and word of mouth instead of going to the city center.
In addition, more noticeable techniques could also be utilized. Info stands can be placed in front of the hospital or at other places to actively inform people about available green spaces and where to find them. With this, specific areas could be promoted more actively than others. The advantage of this type of interventions is that they cost little money and effort. However, due to their nature, they will probably have little impact on normal practices, only affecting first time and infrequent users of the area.

Physical environment modifiers A more invasive type of intervention consists of physical barriers and restrictions. These force people into certain areas and prevent them from going to other areas. Although, such installments can be the most successful because reaction to them is not optional anymore, several things have to be kept in mind. The first thing is that certain solutions are only acceptable during certain seasons. So, for example relocating parking space close to hospital and university to the fringes of the campus is more acceptable during the summer season than during winter time, unless patients and people with mobility issues can still easily get close to their destination building. Thus it is very important to keep in mind that physical changes should not hinder people in reaching their destinations in time and safely. For example, hospital staff who need to attend an emergency should not be hindered too strongly by lack of parking space. Therefore, the appropriate use of all physical spaces should be modeled carefully in order to get better insights in changes of these physical spaces. The advantage of these types of interventions is that they may also change social practices and habits. However, unexpected behavior may result from trying to keep to practices and habits by replanning and using unwanted alternative actions. E.g. parking in forbidden zones, shifting work hours, etc.

Policies and regulations The authorities of the hospital, university and municipality can enforce new policies that require certain behavior of the users of

the campus area. E.g. working hours can be regulated to impact the amount of peak traffic, parking licenses can be given to certain types of employees etc. Policies and regulations have a similar effect as physical interventions if seen as constraints on behavior. However, they also have motivating and knowledge components that promote a certain type of values and thus reward people behaving according to the desired values. This might create a more general behavior change over the long term. However, regulations can also be violated and, if not uphold effectively, will have no visible effect at all.

The sandbox should have an interface that, in addition to allowing the design and insertion of the above discussed desired interventions into the simulations, effectively communicates key concepts to the users. For instance, that behavior change takes time and works differently for people following long term habits and practices and people that have no set ways yet. Thus we should be able to show not just how much success a certain intervention has, but also which types of agents successfully respond to the intervention. E.g. a temporary parking restriction might form new practices for infrequent and new users of the area, while having little impact on the regular users. Visualizing these differences is an important issue, as it influences the decision of whether to stick to a longer-term intervention or to try another intervention based on the results. Or maybe try a different combination specifically targeted at these groups.

The above requirements are the starting point of the model for our simulation. Given the types of interventions supported and the type of interface provided the municipality can use the developed simulation to test different ideas and solutions. Based on the results an informed decision can be made and tested in practice with lesser costs and with more chance of success. However, in case anything is missing or none of the provided solutions are satisfying for the municipality, feedback can be provided, and the simulation can be adapted accordingly.

3.1 Entities

Given the requirements discussed in the previous section we need to distinguish different groups of individuals in the simulation. First, there is the staff that works at the hospital, such as the doctors and nurses. They come into the hospital every day, and are likely to have set behavioral patterns. The second and third groups are the university staff and students, which go to the university every day as well (or at least regularly) - thus also likely to have set behavioral patterns. This group of students makes more use of the green space between university and hospital and it would be interesting to investigate which differences in knowledge and behavioral patterns account for this. Is this mainly due to the freedom in time students have? Or do other features play a role?

Other groups of individuals are the patients and their families, both long term and short term. These groups are particularly interesting since they do not spend as much time around the hospital and might not know the area well, which means that they do not have any set patterns in the area. They also have a large variety of reasons for visiting the hospital, which can determine their willingness or ability

to make use of the surrounding green areas, and thus how receptive they are to possible interventions.

The last group in the simulation are traffic participants. All previously mentioned groups are traffic participants at times because they move around the city to get to work, classes or the hospital, but they are not the only ones to pass through the area. This additional, unrelated traffic, can act as barrier when it passes over roads between the hospital and green areas and thus make other agents less likely to cross from one to the other.

3.2 Time and Geographic Scales

We consider three different timescales in our simulation: days, weeks and seasons. During one day, the agents commute to and from work or school, go to appointments or run errands, have lunch, and find ways to occupy their free time. During one week, agents have different duties and free time on workdays and weekends, and thus different behaviors too.

Seasons have dramatically different weather in Umeå, with very cold, snowy, dark winters and warm, light summers. Spring and autumn are a mixed bag, with the notable feature that temperature fluctuates, which causes roads to become very icy, and walking outside becomes hazardous. Weather is definitely a deciding factor in deciding to go outside at all, never mind spending time in a park.

The geographical scale covers the university and hospital area in detail. Buildings, roads, cycling paths, walking paths, parking lots, bus stops, and parks are all represented to scale thanks to the available geo-data. Outside this area, the only features we represent are the main traffic arteries because we are only interested in the details of people's movements once they get to the university or the hospital. Inside the buildings we only need crude area descriptions, such as lecture rooms, hospital wards, examination rooms, etc. Mainly these distinction will be used to determine where people enter and leave the buildings and how mobile they are within the buildings.

A map of the hospital and university areas is shown in Figure 1. All details outside the areas of interest faded out, with the exception of roads and paths leading in and out of the area.

3.3 Cognitive and social aspects

The cognitive and social aspects that are relevant in our case are goals, knowledge, social practices, habits, norms and values.

Goals are states which the agents are trying to achieve through their behavior. Thus, in this simulation, they are the principle drivers of behavior. We can have goals with sub-goals, such as getting to an examination room is a sub-goal for a goal of hospital visit for a patient.

Social practices and habits are partial plans that are used as defaults in the larger plans for achieving goals. These partial plans are interesting because they are resistant to change and thus special circumstances need to be created in order to overcome this resistance. Also, the longer they have been in place, the harder to

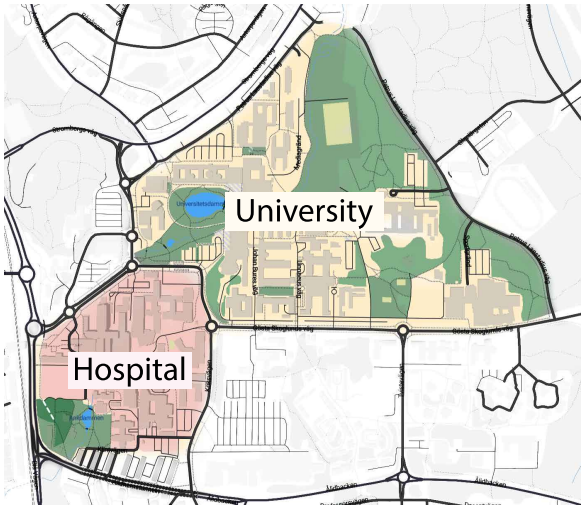

Fig. 1. A map of the university and hospital areas. The hospital area and the campus are fully detailed, with the rest of the map faded out, except for roads and pathways.

change they become. This means that habits and social practices, once established, are followed automatically and preferred over all alternative plans, even when other plans become more beneficial in some way.

We consider habits to be harder to change than social practices because habits are more personal, and thus less likely to respond to social pressure. This part of the model is based on [7].

Norms are used in the implementation to model regulations of the different institutions that make use of the campus. However, they also can encompass norms such as: a patient should be in time for her appointment with a doctor and students should be in time for a class. It is clear that people keep their appointments with a doctor more strict than students are in time for class. This illustrates that norms can be violated, although they always have some influence on behavior. The existing norms might also interfere with new policies that are created for the simulation and therefore are important to model. This aspect is modeled based on [9].

Knowledge defines how many alternative behavior options an agent is aware of and also determines the expected effects of certain behavior. The more knowledge an agent has, the more plans it can build in order to achieve its goals and the better it knows all the effects of these plans. For instance, an agent that wants to pleasantly spend an hour of free time and is aware of the existence and location of the green areas in the vicinity can plan to visit one of them, whereas an agent who lacks this knowledge, may choose to read a book or watch TV inside. It is important to note that knowledge by itself does not determine or change either plans or goals, it just increases options to choose from.

Finally, values are the overarching concept that ties every other cognitive and social aspect together and establishes preferences between alternatives when neither of the other aspects can be used to definitively choose. Values also determine which

kind of changes an agent will be more likely to make since the goals, habits and social practices an agents has in the first place are all dependent on its values. See e.g. [4] for ways to model this aspect.

3.4 Expected results

Regarding the simulation outcomes, we expect results to depend on the invasiveness of the intervention. Therefore, the general expectations can be divided as follows.

For the least invasive, like putting up posters or providing information material at information desks or at the reception of the hotel, a slow starting rate should be expected. Most of the people will recognize the information and read it but also forget it soon afterwards if they are not really interested in it. However, it can be possible that the rate strongly increases after some time when enough people use the new green spaces and so make these areas more prominent to others. Habits, as referred to as solo social practices earlier, can then become general social practices.

The expectations of more invasive intervention techniques should be different, however. When placing info stands, it is more likely that the usage of new green spaces can happen faster because people are informed more directly, benefits can be promoted more heavily, and questions can be resolved. Thus, the knowledge about available green spaces can be strongly increased and people can be motivated more actively to change their habits.

The fastest change can be expected when implementing physical interventions by e.g. relocating parking places or opening or closing entrances to buildings since this forces people to react. They key aspect here is that reaction is not optional, like in the cases before, but rather necessary because previous options are not available anymore. However, it is not certain that the desired behavior change is going to happen. It can be possible that previously neglected options are becoming more attractive now and, thus, it is not certain that new options are considered but rather older options which have been available before but have been deemed less valuable than the chosen option which is now not available anymore. Nonetheless, a change of habits and social practices is enforced which also affects the knowledge aspect. If people want to reach their goal to go outside, they are forced to increase their knowledge about available places. Another thing which has to be kept in mind here is that it is not possible to install too many barriers because the daily business has to continue as usual and as smoothly as possible.

The impact of implementing new wellness policies strongly depends on their enforcement. The more strictly they are enforced, and the harder violations are punished, the more likely it is that new social practices get adopted and behavior change is going to happen.

4 Discussion

The data collected from the municipality gives us a base to describe the daily behavior of the users of the hospital and university space. It also gives a basis for distinguishing a number of important types of people that have different reasons

to make use of the area. This information is important as it serves as the starting point for experimenting with interventions to change behavior.

We start with an assumption that people have an inherent resistance to behavior change. I.e. if they have a practice or habit, they would like to stick to it even though it might not be the optimal behavior (anymore). This implies that people do not change their practices on the basis of new information, and that information-based interventions are more likely to work on people that are new to the area and have not yet had time to develop habits or social practices.

Another important consequence of the resistance to change is that people tend to stick to their (sub)goals as long as possible. If their usual behavior is no longer possible or made difficult, they will try to create an alternative plan for the same goal. Only when their goal is no longer attainable, will they create alternative goals based on their values and opportunities. Thus, this will give a good prediction on how people react to changes in the environment.

The cognitive model required to model this behavior change is quite complex, but will give a detailed insight in changes of behavior. However, simulations that have agents with these rich models are not easily scalable. We estimate that we can run simulations with maybe a few hundred of these agents in real time. In order to scale up the simulation we have to simplify the agents in a useful way. Our proposal is to do this not by having one simulation that can have both scales at the same time, but rather use two different simulations. The first simulation uses the rich cognitive models and studies the individual behavioral changes based on the interventions. We analyze the behavioral changes in detail and classify them based on the characteristic of the models. E.g. individuals that are working as staff at the university and are concerned about the environment will usually respond to incentives to bike to work. This response will depend on the importance of their environmental value and how strong their habit is.

There will be a distribution of these values over the category of university staff that can then be used as a probabilistic measure on how this category of individuals will respond to an intervention. Thus we replace detailed deliberations based on complete models with probabilistic rules for categories. These much simpler rules can be used for the agents in a new simulation with a far larger scale to investigate the effects on a realistic scale model.

5 Future research

Future research will focus on developing the parts of the sandbox that interface with the policy makers (or even the general public) in order to create a digital alternative to the ComMod approach to participatory modelling [3]. Interface and user experience design is not trivial in the case of a software that aims to both be easy to use and easily communicate complex concepts and dynamics to people who are generally unfamiliar with the theory behind agent models, complex systems, or social and cognitive architectures. Parceling out information in useful amounts at useful moments or clearly guiding the user through possible courses of action

will almost certainly require experimentation through multiple iterations. However, the advantages offered by such a sandbox in facilitating the collaboration between policy makers and model developers are worth the effort it would take to make it a reality.

Bibliography

[1] Balke, T., Roberts, T., Xenitidou, M., Gilbert, N.: Modelling Energy-Consuming Social Practices as Agents. In: Miguel, F., Amblard, F., Barcelo, J., Madella, M. (eds.) Advances in Computational Social Science and Social Simulation. University of Barcelona (2014)

[2] Dechesne, F., Di Tosto, G., Dignum, V., Dignum, F.: No smoking here: Values, norms and culture in multi-agent systems. Artificial Intelligence and Law **21**(1), 79–107 (2013)

[3] Étienne, M.: Companion modelling: a participatory approach to support sustainable development. Springer Science & Business Media (2013)

[4] Heidari, S., Jensen, M., Dignum, F.: Simulations with Values. In: International Conference on Social Simulation (2018)

[5] Klein, M., Mogles, N., van Wissen, A.: Why won't you do what's good for you? using intelligent support for behavior change. In: Salah, A.A., Lepri, B. (eds.) Human Behavior Understanding. pp. 104–115. Springer Berlin Heidelberg, Berlin, Heidelberg (2011)

[6] Lally, P., van Jaarsveld, C.H.M., Potts, H.W.W., Wardle, J.: How are habits formed: Modelling habit formation in the real world. European Journal of Social Psychology **40**(6), 998–1009 (2010)

[7] Mercuur, R., Dignum, F., Kashima, Y.: Changing Habits Using Contextualized Decision Making. In: Jager, W.e. (ed.) Advances in Social Simulation 2015. pp. 267–272. Springer (2017)

[8] Nooitgedagt, A., Beun, R., Dignum, F.: e-coaching for intensive cardiac rehabilitation - a requirement analysis. In: Persuasive Technology: Development and Implementation of Personalized Technologies to Change Attitudes and Behaviors - 12th International Conference, PERSUASIVE 2017, Amsterdam, The Netherlands, April 4-6, 2017, Proceedings. pp. 31–42 (2017)

[9] Pastrav, C., Dignum, F.: Norms in social simulation: balancing between realism and scalability. In: Proceedings of the Fourteenth International Social Simulation Conference (2018)

[10] Region Västerbotten: Regionvård vid Norrlands universitetssjukhus. `https://www.regionvasterbotten.se/VLL/Filer/Regionv%C3%A5rd%20vid%20Norrlands%20universitetssjukhus%202018.pdf`

[11] Schwartz, S.H.: Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries. Advances in Experimental Social Psychology **25**(C), 1–65 (1992)

[12] Shove, E., Pantzar, M., Watson, M.: The Dynamics of Social Practice. Sage (2012)

[13] Slotte, J., Indebetou, L.: Resvanor i Umeå Så reste kommuninvånarna hösten 2014 (2014), `https://www.umea.se/download/18.7400452514df41e0121ea29/1435319696817/`

[14] Tobias, R.: Changing behavior by memory aids: A social psychological model of prospective memory and habit development tested with dynamic field data. Psychological Review **116**(2), 408–438 (2009)