FROM QUANTIFIED SELF TO QUANTIFIED NEIGHBORHOOD

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ABSTRACT

The past decade has shown a great rise in digital tools to measure various aspects of daily life. Such measured data does not exist in a vacuum and is increasingly integrated in newly designed interactive products. Meanwhile our cities are moving toward smart infrastructure and supporting innovation from citizen initiatives to improve the urban experience and well-being. In the current work we follow these trends by building on the design knowledge created from the designing of personal informatics and bridge this knowledge towards urban informatics solutions. We elaborate upon the stage-based model of personal informatics (Li et al., 2010) and how it can be potentially applied on a neighborhood level. We discuss the proposed expansion from a personal model towards a participatory one and highlight the design decisions regarding motivation and community forming, and present a design case to illustrate the holistic activities of a designer contributing to a community-deployed, quantified project.

INTRODUCTION

Data is increasingly everywhere surrounding our urban life, generated by the supporting infrastructures (like the traffic or the sewage system, see for example: Hull et al., 2006), mobile devices in our pockets and even by wearable devices worn on our bodies. Differently put, our digital footprint intertwines with the physical world, and is studied in the field of Urban Informatics (see Foth et al., 2011).

Designers have addressed the design of personal mobile devices for decades already, although the design knowledge has been captured mainly in the field of personal informatics, defined as "*a class of systems that help people collect personal information to improve self-knowledge"* (Li et al., 2010). Research from the field of personal informatics has shown that sensorial data from personal devices such as smartphones or wearables can be used for giving individuals better insights about their behavior and activities, as well as for motivating "better behavior", such as healthier or more sustainable living.

Next to the academic research on creating new personal devices and services, people have been increasingly using their personal devices in order to gain better insights about one's life, especially to reach a greater awareness of personal health in order to improve it (see for example: Swan, 2009). This social movement has been referred to as Quantified Self[1]. Quantified Self has been a successful, trending phenomenon all over the world with increasing number of people joining to track daily life for new insights. The rise of wearables has lowered the barrier for anyone to participate and thus has contributed greatly to simplify participation in such self-measuring.

It is interesting to consider the parallel of personal informatics and urban informatics, because people do not live in a vacuum but in households, which are integrated in the physical space. We could start measuring our environments the same way as it is possible to track our health with personal devices, which are increasingly connected. Burke and colleagues (2006) address that *"everyday mobile devices, such as cellular phones [..] form interactive, participatory*

[1] http://quantifiedself.com/about

sensor networks that enable public and professional users to gather, analyze and share local knowledge". This so-called *participatory sensing* enables a neighborhood to collect data about themselves, analyze the findings and decide on actions based on them. Committed governments are seeking for innovative ways to serve their citizens better, and to establish better policies (see for example, Stembert et al., 2013). Properly quantified data regarding a community can be a promising and informative foundation for an evidence-based conversation. This is keeping with the points raised by Weise and his colleagues (2012) about the democratization of ubiquitous computing infrastructure. In their view, ubiquitous computing research need to pursue further how non-experts could build upon the infrastructure in their locality.

Elaborating upon the initiatives of Quantified Self and Participatory Sensing, the time seems ripe for "quantified neighborhoods", i.e., communities of people living in close proximity, measuring their environment together and sharing the data for insights. However, Personal Informatics is mainly concerned with the Human-Computer Interaction (HCI) aspects of Quantified Self. Similarly, Participatory Sensing focuses on the technological discourse, and neglects the social and design elements. In the current work, we explore the opportunities and challenges in designerly ways to achieve increased neighborhood participation by encouraging participatory sensing.

Hereto, we elaborate upon the stage-based model of personal informatics (Li et al., 2010) for use in the context of urban informatics. While the model of Li and colleagues is rooted in HCI, our proposed design approach allows to frame participatory design challenges from a personal perspective towards a collective one, in order to enable neighborhoods to collect data about themselves. The gained insights are in the first place meaningful primarily to the citizens of a neighborhood themselves. However, in the next step these may also inform the design of new public services in the context of urban planning, policy-making or public health. Although privacy is crucial and relevant, – particularly when it comes to personal data and handling personal data – extensive analysis of this aspect is left out of the scope of the current work.

TOWARDS A PARTICIPATORY MODEL

According to Li and his colleagues (2010), *"the stage-based model extends our view of personal informatics systems beyond a pairing of collection and reflection tools"* . An illustrative example of the pairing of collection and reflection tools is: recording data by pen or a digital spreadsheet (e.g., someone's measured weight every day), and then plotting the data as a time series. Furthermore, the model by Li et al. (2010) extensively discusses the different stages what happens before, between and after the *'collection'* and *'reflection'* resulting in a design method where designers and developers can give a focus for such questions as *'How to design an easy learning curve for the users?'* or *'How to maintain motivation to keep the system in use?'*

The stage-based model of personal informatics considers a single user for the whole loop of working with personal information (Li et al., 2010). **Figure 1** shows our proposed extended stage-based model for participatory urban informatics, and refers to possible design approaches for each stage. When it comes to applying the model for participatory urban informatics, some considerations are needed for expanding the model. These are addressed below:

1) COMMUNITY SYSTEMS
Instead of a *personal* system, the designed solutions must work with *multiple* users (communities). The solution should increase the sense of community and provide individual benefits for collaboration. The design of such systems has been discussed extensively in the field of *Community informatics* (Gurstein, 1999).

2) PERSONAL GAINS OF SHARING
The designed solutions should combine the data collected and shared by the individuals (e.g., external air quality or noise level) in such a manner that the insights gained are meaningful for both the community as well as for the individuals themselves. However, motivating the participation and the involvement of individuals is a design problem that should be tackled in the Preparation and Action stages of the model (see **Figure 1**) by for instance applying persuasive design principles (Fogg, 2003).

3) INSIGHTS
The main aim of a quantified neighborhood is to provide meaningful insights of a neighborhood for individuals and a community. The designers' role in this is facilitating a co-creation process with different stakeholders. The final solution should allow individuals (and the community) to explore and learn from the available data, as well as to propose improvements in order to incorporate new measurements.

4) DATA HANDLING AND PRIVACY
Collecting and sharing any type of personal data raises concerns regarding privacy matters. Firstly, users may be hesitant to share their data with other users or governments. Secondly, there is a risk of security breach and abuse of data, like with every system. Thirdly, the ownership of shared data is a legal gray zone in many countries. All these aspects need to be tackled throughout the (participatory) design process.

DESIGN CASE

In this section we illustrate the use of the model through an exemplary design case of a neighborhood project for measuring air quality. Our proposed model expands from the personal scope towards a community, thus the design case is also focused on such an approach.

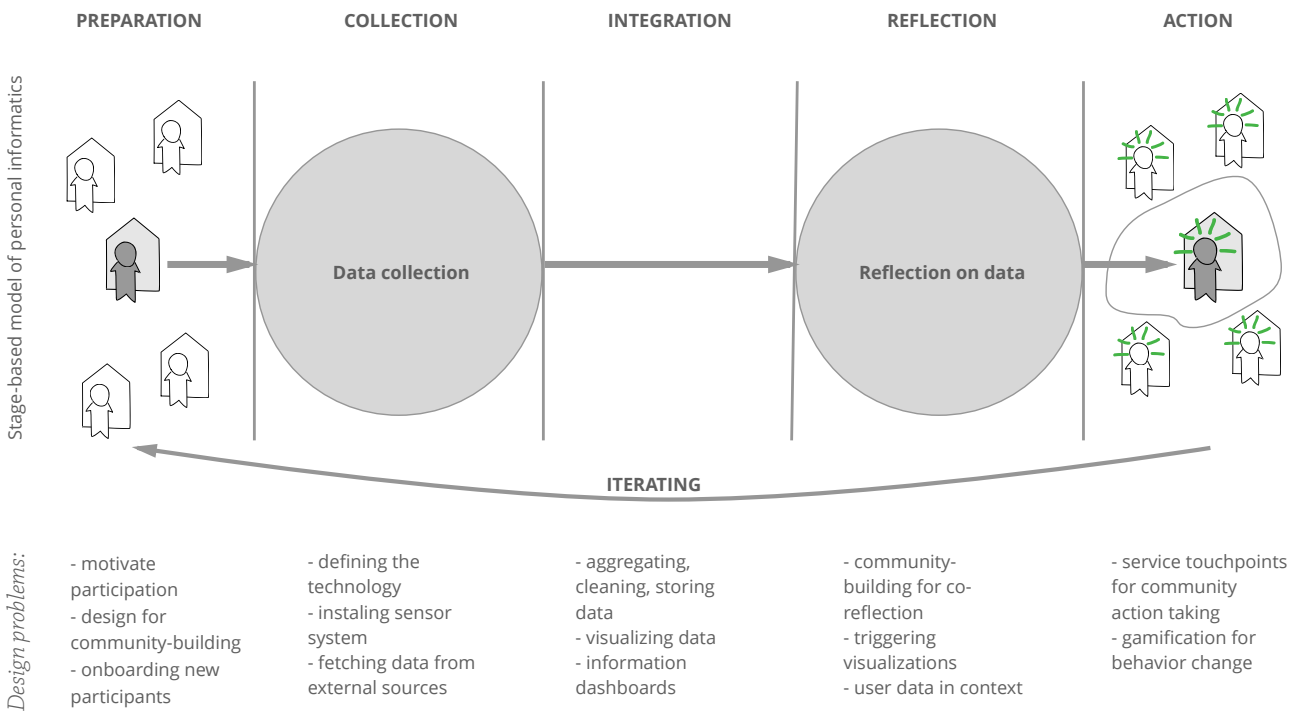

Figure 1: Extended stage-based model for participatory urban informatics

In the current section we refer to a design problem as a problem, which requires a designer to analyze possible solutions, while balancing between technology, viability, aesthetic, and other constraints, in order to reach an optimal decision. As such, a design problem is not a typical neighborhood or community problem. We also state different activities designers need to conduct during the various stages of the process. The processes start out from out perspective of participatory design, where the designer is seen as the facilitator of the design process. However, different community members may also have a designer role.

Scoping our running example:

Our persona, Felix lives in a bustling Western European city with smart city initiatives. Felix lives in a neighborhood near the center with average demographics. He considers himself a computer proficient person, but is not skilled in programming or electronics.

Felix has been interested in quantifying some parts of his life and he can see potential value in longitudinal data collection. For instance, he previously had kept track of his calorie intake, weight changes and running routes with smartphone apps.

Felix and his neighbors would like to see similar positive benefits from quantifying their extended environment. However it is daunting for them to start, lacking experience and knowledge how could this be approached and what kind of exact benefits they could get from it.

How to expand *'personal'* towards a collective is not straightforward; these people can form a community either online or offline, based on a shared interest (hobbies), life situation (pregnancy) or by physical proximity: a neighborhood or tenants in a residential building. Consequently, the design space and design problems increase in complexity.

1) PREPARATION STAGE

Felix needs to consider how to motivate his neighbors to participate in tracking air quality, and how to reach out to people he does not know yet.

A main design problem to solve in the **Preparation** stage is to motivate participation for a quantified neighborhood. Several theories have been solidified in HCI for motivation; among these promising ones for a quantified neighborhood are persuasive design (Fogg, 2003), gamification (Deterding et al., 2011), etc.

The above-mentioned 'designed' motivational methods (persuasion, gamification, etc) may work with a given user, but might fail for another. Thus, a deep understanding of the community members is required to be able to adapt different methods to the right group of the community. Furthermore, the designer needs to assess who should participate in the quantification: the complete neighborhood, or only a subset like early adapters or technology interested people.

During the **Preparation** stage the designer needs to assess the importance of community building as a design goal, and translate it into design constraints. It may be realistic that people in the same neighborhood seldom talk/know each other, and a common quantified

neighborhood project would potentially connect them. The core design problem is to connect the individuals and form a community out of a task group (Mulder et al., 2002). Different personal informatics systems have answered this by such solutions as leaderboards (i.e., acquaintances challenging each other) or by enabling collaboration for a shared cause (e.g., reporting traffic information with Waze[2]). With the different upcoming sharing economy trends, there are indications that these potentially work on the long-term.

The scenario can also be differentiated between starting up a project from scratch or onboarding new participants into an already ongoing project. Often overlooked, but the latter aspect should be considered from the early stages of realizing the project, to ensure that it can be deployed for long-term.

2) COLLECTION STAGE

After Felix managed to convince a starter group in his neighborhood to act on the air quality, they find themselves with the question: "How to measure air quality in our neighborhood?" After some technical consideration, they order some prototyping electronics kits online and install these sensors in their external windowsills all around the neighborhood.

The **Collection** stage defines the exact method how the data is collected in the neighborhood. This can span from all sorts of environment sensors (temperature, air quality, noise, etc.), but may be triangulated as well by monitoring social media (geo-tagged posts) or solved lo-tech as counting people or traffic by pen and paper. It is important to note, that the data do not need to come from sensors installed by the users; governmental open data is equally valuable for this stage, and such datasets and data feeds may contain information about such kind of phenomenon, which would be hard to measure by individual sensors (such as traffic passing by).

Depending on how data collection is exactly realized, there are different design problems to address. For the situation when the quantification happens by the means of sensors installed by the users, the main motivation problem is to balance the ease of installation and the overall cost of sensors (note that the cost can be addressed by alternative business models also).

Data may also be collected from open data feeds. From the abundance of different datasets and feeds, it is difficult to choose what kind of data could be valuable for the neighborhood. In the beginning, this scenario requires virtually almost no investment; anyone with computer development skills could explore the open data sets available and prototype different projects based on them. However, such explorations tend to remain unpublished or not promoted; these are more of hobby projects of curious individuals. In case such hobby projects are found, the designer or the users from the neighborhood could build on such projects, thus exploration of skillful individuals for a project might make such people key people (also so-called lead users) in the community.

Interestingly, community data collection is also developing into commercial products. For example, Smart Citizen Kit[3] and the Air Quality Egg[4] were successfully funded through crowd-funding, they enable anyone to install an environmental sensor at their home (or office) and connect the sensor to the cloud. The measurements by the devices are continuously updated to the cloud, where anyone can see the air quality (or other environmental parameters) at given location at the actual moment or as time series. These products are however still under development; their user base is still mainly consists of 'early adapters' and the technology is also under constant development.

3) INTEGRATION STAGE

Felix and the neighborhood find a computer developer interested in participating in the project, who offers her help with aggregating and visualizing the data on a local server. The developer creates some basic program the participants can run for their air quality sensors and the program uploads the measurements to the cloud and summarizes them for later queries.

Having access to the collected data is essential for a successful project, but it is also necessary to have the data aggregated, processed (e.g., cleaned), stored somewhere. All these different sub-steps encapsulate the **Integration** stage. Although this stage is largely technical at the beginning, in the end the results are going to face the users. In other words, the designer needs to address this issue with great consideration.

Data-related projects can easily fail because data are hard to access or are presented in a hardly comprehendible way. The easiest and safest direction to solve the integration of data is to visualize it on the user interface. This visualization can support the users' cognition in understanding trends from the data, or by supporting the cognitive processes by providing appropriate context.

Visualization of data often happens with information dashboards (Few, 2006). Most often there are more than one kind of aspect, which can be understood from the data. A dashboard can easily summarize multiple parameters; this may be: current air quality status, air quality certain time ago (1 week, 1 month, 1 year ago – helpful to compare trends), a bar chart diagram plotting the air quality measures of the last 24 hours (or 1 week, etc.) and so forth.

[2] https://www.waze.com/

[3] https://smartcitizen.me/

[4] http://airqualityegg.com/

4) REFLECTION STAGE

Felix's neighborhood has been following the air quality measurements over several weeks time. They opened a private chat room on a popular social networking site, where they can leave messages to each other (such as alerting a user that his sensor is providing possibly false data). The community also started to follow the diagrams of daily air quality and they started to notice certain patterns, such as a peculiar air quality peak on Monday mornings.

A promising element of a quantified neighborhood is to answer the question: *What can be learned from the collected and integrated data?* The reflection stage provides mainly insights for the users.

The design decisions at the **Reflection** stage influence the depth of insights possible to provide. Different kind of visualizations can be used for providing better awareness of a certain phenomenon (e.g., air quality, energy consumption). However, visualization can differ in its technical solution: most commonly, the designers can consider a virtual dashboard on a website or a smartphone app, for example to overlay a heatmap plotted on the map of the neighborhood. Furthermore, the data can be visualized on a public installation, such as a media façade (Wouters et al., 2014) or a physical data sculpture (Zhao and Vande Moere, 2008).

Deciding on the type of visualization can differ based on different design intents. Likely the interest is going to drop with time after the novelty period is over. The main motivation aspect for the reflection stage is to provide valuable learning via the visualization. An additional aspect for the designer is to consider providing extra information to break monotony: to trigger the user an extra incentive for returning. Such triggers can be showing insightful information, which can react to the behavior change of the user: for example showing predictions (i.e., trendlines) that can be directly influenced by consistent behavior.

Alternatively, the user's activity can be also compared to his/her earlier activity; in this case the comparison is based on historical data. This technique is also often used by various personal informatics platforms, for example for weight loss or running performance, especially in scenarios when the user does not feel comfortable sharing her progress.

5) ACTION STAGE

Felix and his neighbors have started to regularly meet for an evening to discuss their learnings from monitoring their air quality in the neighborhood. During these meetings they have concluded to approach the municipality to share their observations and to seek for options whether the peaking hours of bad air quality could be optimized, e.g., by rescheduling the garbage trucks. After the success of the air quality project, Felix and his neighbors are also considering to expand the sensors towards monitoring the noise level.

The **action** stage is the end of the loop for the model, and therefore the considerations of the designer are mainly to ensure that the user remains interested and involved. Besides sustaining long-term interest and involvement, the last focus area of a designer is to trigger the user to act on her reflections.

A possible way to ensure action is to design further service touchpoints in order to create reflection and co-reflection opportunities for the users. Example touchpoints could be a regular community meeting where the participants meet to discuss the measured information. A series of events like that can provide a platform to cast transformational change in the area. These touchpoints can be part of a transformational 'citizen and government' dialogue too.

Interesting ways to design the community element is by providing the opportunity to compare the users' collected data to the data of other users. Comparing to others is often found motivating (as of winning against someone in a competition), and may encourage pro-social behavior by confronting the user of over-consumption for example. A potential risk is however the possible scenario that the activity of other users is neither inspirational nor exemplary.

For a quantified neighborhood, motivating action can happen for instance by encouraging neighborhood transformation (e.g., social movements) where the users collectively act on the learning. For instance if the finding shows that the garbage should be collected one day earlier, such suggestions can be directed to the government. When the users sense that the quantification has tangible benefits, motivation will remain stronger and likely have a sustaining effect.

DISCUSSION

It is not straightforward how personal health tracking devices maintain long-term motivation of use. Lessons learned in Quantified Self need to be taken into account for designing quantified neighbourhood projects. Next, projects deployed for communities can benefit from different business models and environments. For instance recycling as a public utility works in cities where the infrastructure is developed towards, and it is just easier for a user to be part of the system than not.

There are two main design issues to solve for designing quantified community projects. Firstly, how the data is collected and if there are meaningful insights from it provided for the users. Secondly, as a community project only provides value if people are involved, participation should be motivated and nurtured.

If the Stage-based model is considered during the design process, we recommend approaching the **Collection** – **Integration** – **Reflection** stages together for designing the "data part" and then the **Preparation** and **Action** stages to design the participation element. This approach is more realistic for an iterative design process as well: at most times, the first prototypes are going to

be around building the core system, which is the data collection and visualization. Furthermore, dividing up the design process between different areas (*data collection*, *motivation*, *community building*, etc.) also enables to iterate on one aspect at a time.

The privacy considerations for personal informatics products are more straightforward than for community projects. As discussed earlier, a community may benefit more from collecting and using semi-private data, but this raises concerns for handling privacy. In the medical domain the same problem has resulted in anonymizing techniques, and these shall be a direction for future work in enabling quantified neighborhoods.

CONCLUSIONS

In the current work, we proposed a modified design method based on the Stage-based model of Personal Informatics by Li et al. (2010) for urban informatics cases. The usage of the stage-based process was illustrated with a running example and a discussion on the holistic design decisions for realizing such a project.

The social impact of a quantified neighborhood is its transformational power to initialize an evidence-based dialogue with the government. A quantified neighborhood is independent (similar to 'grassroot') and user-centered around actual problems. It has the potential to be a bottom-up movement, which can trigger bigger changes in policy-making. Furthermore, a quantified neighborhood project creates a trigger to connect people living in the same neighborhood.

With the rise of the *"maker culture"*, produsage of simple electronic prototyping (De Paoli and Storni, 2011), regular users (i.e., citizens) can more and more easily realize such projects as a quantified neighborhood. Besides the lowering threshold to build such systems hands-on, there is also the trend of – often crowd-funded – consumer products enabling data collection of the user's environments. We hope that these precursors are indicating a new era in ubiquitous computing and smart cities, which is based on the culture of participation, instead of a conversation dominated by networking companies.

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