

# Meaningful Interactions in a Smart City

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**Abstract.** A city is a public space where people find meaning by living together. Although cities are governed by city councils, it is mainly the citizens that make their own city. The contemporary cityscape is increasingly pervaded with emerging media. Recent invasions of interactive media in the cityscape, however, are to a large extent commercial broadcasting systems that do not encourage interaction and communication among citizens. This is not trivial; the public space is the city's medium for communication with its citizens. The current work derives from the notion that interactive media can be used to enrich people's lives in a meaningful way. In three design cases is illustrated how the symbolic level of interactions is of major importance for designing meaningful interactions in cities.

**Keywords:** Smart city, interaction design, meaning, human values.

## 1 Introduction

In the Meaningful Design in the City programme of research centre Creating010 we investigate how to design for smart cities in a human-centred way. Originally, research on Internet of Things and Big Data generally focus on connecting a variety of information systems and data sets, including physical objects such as bus stops, billboards, waste containers and devices like smart watches and other wearables, in order to optimise processes in the field of traffic management, mobility, energy, security, or shopping. In doing so, the position of the individual might be ignored by the organisational goals of governments and companies. In contrast, research centre Creating010 studies how the design process on an urban interaction level can be people-led. The accompanying values-based approach starts from out the needs, goals and values of individuals and groups of people in the city. That is what we call meaningful design. In doing that, not so much an Internet of Things is the objective here, as well as an Internet of People [1]. The central question in the Meaningful Design programme is: how to provide meaningful experiences by exploiting omnipresent technologies. Technology that is accessible for people to influence their local living environment and society at city level. We enable people to invent alternative ways of value creation or product trade systems (economics), to organise themselves to influence local

policy (participation, democracy), and to support and take care for each other (health and well-being). When aligned with organisational goals, this also is an opportunity for governments and companies to improve their proposition and customer experiences. The current contribution describes the challenges for designing hybrid interactive environments that mix pervasive technologies (such as sensors and public displays) in physical spaces with virtual (social media and individual) content (data), to create the experience of meaning over time and space in cities. We introduce three design cases to illustrate how accounting for human values improves the symbolic features in the design for meaningful interactions throughout time and space in the city.

### 1.1 Human Values and the Experience of Meaning in Interactions

Early work on human values [2, 3, 4] explains how human values drive people's attitude and behaviour. The insight that addressing people's values result in stronger product and brand preferences of consumers, is widely used since then in the marketing and market research industry for product development, communication, and advertising purposes [5, 6, 7]. One characteristic of human values according to Schwartz [4] is that they refer to desirable goals that motivate action. According to Csikszentmihalyi [8] one element of the experience of meaning is an 'ultimate goal' (or reason of living). Human values probably are the most important goals in life of people, according to the definition of Rokeach [2]: "an enduring belief that a specific mode of conduct or end state of existence is personally or socially preferable to an opposite or converse mode of conduct or end state of its existence". Another characteristic mentioned by Schwartz [4] is that values are beliefs that are linked inextricably to affect. Once values are 'activated' they become infused with feelings. In the field of emotional design, Desmet's [9] model of product emotion reflects this process: emotions emerge from an appraisal process in which (external) stimuli are weighted against one's (internal) concerns such as human values. In summary, from out their human values people envision an ideal world to pursue that gives meaning to life. Based on that we define 'meaningful design' as 'design that accounts for human values and empower people in pursuing life goals'. In order to explore how designers can evoke meaningful experiences with their artefacts we found that in user experience (UX) research instrumental, task-oriented, (pragmatic) goals are distinguished from non-instrumental (hedonistic) goals such as beauty [10, 11, 12, 13]. Few researchers describe instrumentality, aesthetics and symbolism as integrated aspects in one design [14, 15]. Based on earlier work from UX research, we made a generalisation of three levels of experiences as results from specific features of design disciplines. Table 1 shows these three levels, which are: aesthetic experiences based on sensory perceivable properties of artefacts, experiential experiences based on the behaviour of artefacts, and symbolic experiences based on the extent to which artefacts comply to our values [16].

**Table 1.** Three levels of experience of design. Information processing in design models [16].

Generalisa- tion	Aesthetic: How it <i>feels</i>	Experiential: How it <i>works</i>	Symbolic: What it <i>means</i>
Design fea- tures	Inherent qualities, formal properties, appearance, physical properties, first impressions	Interaction, performance, instrumental benefits of use	What it says about ourselves and others, memories, appraisals of motive compliance against concerns (goals and values)
Experience duration	Immediate	Short-term, mid-term	Long-term
Design disci- pline	Visual design, sensorial design	Interaction design, information architects, network engineering, software engineering	Brand experience designers, artists, story-tellers

While specific disciplines focus on specific features of design resulting in certain types of experiences, we conclude that the most rich user experience result from designs for which the designer achieved to integrate all features as a whole. When it comes to designing single artefacts such as a website or a smartphone app, designing for aesthetic, experiential, as well as symbolic experiences is already a challenge. Without doubt, the challenge to design in a meaningful way for smart cities, which are complicated large-scale urban technological ecosystems that are present always and everywhere, becomes even bigger.

## 1.2 Time and Space

Now pervasive technology is present everywhere and all the time, it has is impact on the way people experience the city. We argue that space and time deserve more attention as factors in the design of meaningful experiences in a smart city. In recent years, among UX researchers attention has grown to the temporal and spatial factors of pervasive technology [17, 18, 19]. With regard to the experience of meaning, efforts are made to measure and explain how user experience evolves over time from orientation through incorporation to identification [20, 21, 22]. Longitudinal and retrospective approaches appear to result in a proper insight in aspects and changes in user experience over time [23, 24]. Where Karapanos et al. [22] indicate meaningfulness to appear in the phase of incorporation with the realisation of usability and usefulness, our definition of meaningfulness would position meaningfulness in the last phase of identification when a product relates to personal experiences, daily rituals and self-expression. Nonetheless, time appears to be an influential factor in the experience of meaning of technology design. Also the aspects of space and place have been thoroughly investigated. Since designing pervasive technology is designing ‘new context’ in which people live, much emphasis has been given already to the embodied

interaction in space and place [25, 26, 27, 28]. An interesting perspective is that of the multiverse presented by Pine and Korn [35] with which they challenge companies to explore the ‘infinite possibilities’ of hybrid realms in the spectrum of time and no-time, space and no-space and matter and no-matter. Harrison et al. [29] stress the importance to focus on embodied interaction, because our location in the physical and social world is crucial in understanding ourselves, the world around us, as well as our interactions. In what they call the third paradigm of HCI, Harrison et al. [29] argue that the question how context gives meaning to the design of technological systems, should be replaced by the question how design of technology accommodate the context. So, much research already has been done on temporal and spatial factors of pervasive technology and also more attention has been given to hedonistic goals next to pragmatic goals in Human-Computer Interaction (HCI). The interplay between these trends reveals new possibilities for the design of meaningful interactions in the real world. In the remainder of this work, we focus on the symbolic aspect of the design for smart cities. Hence, the current aim is to design a ‘meaningful’ experience of the user. In keeping with the third paradigm, we focus on the diversity of human values as ground for making meaning as well [29, 30, 31, 32].

## **2 Moodly, Cosy and Nosey: Three Cases of Meaningful Design**

In the Meaningful Design in the City programme, we work in close collaboration with the City of Rotterdam. Public servants of the local government are connected to certain groups of citizens that aim for improvement of their neighbourhood or societal issues at city level. Rotterdam politicians support alternative ways of influencing city’s policy by citizens. Many governmental services are eager to learn about how to consult citizens and how to involve citizens in crowd-sourced data collection. That demand is a ground for projects that go one step further towards people-led projects. We especially focus on how to design the interactions in-between citizens and between citizens and local government at one hand, and between citizens and the designed technology at the other hand, in order to evoke a meaningful experience for citizens. The cases are used to illustrate the symbolic features of the design, which we have marked with [M] in the following paragraphs.

### **2.1 Moodly: Art Installation for City Emotion Insights**

Moodly is an interactive art installation that allows people to value their mood, and communicates these values through public screens using a mobile app enabling people’s awareness of each other’s emotions. Several physical interactive installations are placed at different semi-public spaces and connected via the (mobile) web application. After gathering real-time data we analyze the mood assessed in different locations in the city of Rotterdam, taking into account the difference among different locations and moments, and compare these Moodly assessments with a wellbeing index based upon public sector information derived from the Rotterdam Open Data Store. In the design project for the interactive cityscape the central question was how

meaningful design can enhance interaction among citizens, cultivate citizens' happiness, and contribute to a city's wellbeing. In this design, private emotions are aggregated into emotional-state-of-the-city maps. Individuals gain insight in how personal emotional states relates to the city crowd emotional state [M]. Personal emotional data is combined with geo-data for mapping to create maps. Other city stakeholders, e.g., the police, can use the categorisation of mood states as indications of emergency situations. The aim is that people experience connectedness by expressing emotions and sharing them with others in the public domain [M]. Multiple physical installations on different locations offer an input device and a display of digital maps of emotions in the city. The input devices can be used over a longer period of time. The installation make visible that an individual is part of a larger city community [M]. All together people make the mood of the city [M].

## 2.2 Cosy: Hybrid Smart Cafe

In the city of Rotterdam, certain districts were initially built just for the purpose of housing workers for nearby industries. In those areas, public spaces for people to gather are rare, even today. The physical infrastructure of these neighbourhoods supports social contacts insufficiently leading to a low social cohesive environment. For social meet-ups, people are making appointments to meet outside their own neighbourhood. Rotterdam New West is such an area for which we are designing a 'smart neighbourhood community cafe'. The design goal was to create a hybrid, 'permanent pop-up' cafe where people can meet and feel at home. This cafe adapts to the goal and preferences of its visitors. By means of social media data (e.g., Facebook, Instagram, Twitter, Spotify, Flickr, Pinterest), sensors, identification technologies, projections and displays, an ecology has been created that transforms its interior and ambiance each time another group of people is present at place. The cafe detects who is inside and projects those persons social media images to the wall, it plays their combined music play-lists, and it communicates publicly in social media who is inside. The ecosystem also offers possibilities to collect preferences from people with regard to drinks and food beforehand that will be served at the moment visitors attend. Distributed individual personal data is merged together with those of others into one physical location. Individual's personal digital information and preferences are blended in a physical social meeting place. Individuals are invited to participate in group meetings with common interests [M]. An important aim is that people experience connectedness and recognition [M]. More social connectedness (cohesion) improves public safety and tidiness, and increase feelings of well-being as well as increase of property value in the long run [M]. Visitors can prepare personal information before meetings and can retrieve information of their activity during meetings afterwards. The strengthened relations give opportunities for easier exchange of knowledge and services. Stronger connections between people improve the experience of safety, tidiness, and connectedness [M].

### 2.3 Nosey: Mobile Device for Real-Time Climate Sensing

Air quality in the urban area of Rotterdam is poor. The City of Rotterdam is struggling in meeting European standards of air quality and seeks for extra measures to improve air quality in the city. Several citizen groups organised themselves to deploy private sensor networks to collect climate data independently from local government as evidence in defending their interests in city policy and politics. Governmental as well as private sensing systems consists of locative sensors that measure only few parameters for air quality over certain periods of time. With Nosey, a mobile device for real-time climate sensing, we aim for a large number of mobile sensor devices that measure air quality in real-time all around the city. The challenge is to design a product-service system in which citizens benefit from carrying the Nosey device throughout the city while the generated data can also be offered as an open dataset in the Rotterdam Open Data Store (and to be combined with other datasets). One of city's stakeholders, the environmental protection agency of local and regional authorities in the Rotterdam area (DCMR), is looking forward to this additional stream of climate data in order to intervene in inconvenient situations and to enforce local, national and European policies. The mobile device is sensing the city's climate state in real-time. Locally sensed air quality measurements are aggregated into high-density real-time maps. Digital sensor data is aggregated and send back to individuals as digital layer on present location. Individual's data contributes to open/public collective mappings of clean and polluted areas in the city. Real-time sensor data is combined with periodically measured data and geo-data. Prediction of critical future climate states based on historical data becomes possible. The aim is that through collecting the data, people experiencing control, independence and achievement [M]. In such way we empower individual citizens to have insights in clean areas for living, commuting, etc. as well as providing local authorities with data for interventions and policy making [M]. The collection of air quality and people insight into it, improves the debate and decision making on air quality policy [M].

## 3 Aspects of Designing Meaningful Interactions in Smart Cities

To get better insight in designing meaningful interactions, we look in more detail at the three design cases to explore the different features that the cases have in common. Based on experiences in student design projects, various challenges are identified and written down on statement cards. Subsequently, these are clustered by two experts. Table 2 shows the corresponding findings, how the designs aim to contribute to meaningful experiences.

**Table 2.** Results of the analysis of three design cases and their common design aspects

Moodly: Interactive art installation allowing people to value and express their mood	Cosy: Smart neighbourhood community cafe	Nosey: Mobile device sensing the city's climate state in real-time	Common aspect
Private emotions are aggregated into emotion- al-state-of-the-city maps	Merging distributed individual personal data together with those of others into one physical location	Aggregate locally sensed air quality measurements into high density real-time maps	<i>Connect the local/small with the global/big</i>
Insight in how personal emotional states relates to the city crowd emotional state.	Individual's personal digital information and preferences are blended in a physical social meeting place.	Individual data contrib- utes to open/public collec- tive mappings of clean and polluted areas in the city.	<i>Create reciprocal connec- tions in-between the personal and the collec- tive</i>
Combination of personal emotion data with geo- data for mapping.	Combination of individu- al's identification and location data with data stored in social media	Combining real-time sensor data with periodi- cally measured data and geo-data	<i>Combine dynamic sensor data and user generated data with static data</i>
Possibility: Categorising mood states as indications of emergency situations for police	Adaptation to preferences of identified person pre- sent at location. Notifying individuals to participate in group meetings with common interests.	Prediction of critical future climate states based on historical data	<i>Bring about intelligence through prediction and/or anticipation</i>
Experiencing connected- ness	Experiencing connected- ness, recognition	Experiencing control, independence and achievement	<i>Make people experience meaning by empowering them to strive for what they value in life (human values)</i>
Expressing emotions and sharing them with others	Social connectedness (cohesion) improves public safety and tidiness, and increase feelings of well-being as well as increase of property value in the long run	Empowering individual citizens to have insights in clean areas for living, commuting, etc. as well as providing local authori- ties with data for inter- ventions and policy mak- ing.	<i>Balance one's individual meaningful experience with the (organisational) concerns of other stake- holders</i>
Physical installation as input device displaying digital maps of emotions in the city The input devices are installed at several places in the city, to be used over a longer period of time	Digital social media information of visitors is made visible in a physical meeting place. Visitors can prepare personal information before meetings and can retrieve information of their activity during meetings afterwards	Digital sensor data is aggregated and send back to individuals as digital layer on present location The device is carried around throughout the city and collects data real- time. The stored historical data can be reviewed later on.	<i>Enrich people's environ- ment to blend physical and digital elements into hybrid places Expand the experience over time and space</i>
The installations is a means of expression in the public domain for people	Stronger relationships give opportunities for easier exchange of knowledge and services	Collaborative generation of air quality data im- proves opportunities for a cleaner thus healthier environment	<i>Encourage value creation by people for people in the city</i>
The installation make visible that an individual is part of a larger city community. All together people make the mood of the city.	Stronger connections between people improve the experience of safety, tidiness and connected- ness. The presence of Cosy also improves meaningful placemaking.	The collection of air quality and people insight into it, improves the debate and decision making on air quality policy.	<i>Make the city as a whole attractive for living and working</i>

## 4 Discussion

Although the three cases were different in scope, several common aspects were found in the design cases. In the remainder of this section, we elaborate on these commonalities and discuss what lessons can be learnt in order to design meaningful interactions in a smart city.

### 4.1 Make It Smart

**Connect the local/small with the global/big.** By aggregating information of individual situations and locations into a collective dataset, new insights in the state of the city as a whole become possible. Connecting virtual as well as physical things (Internet of Things) at personal level with technology in the home and in the neighbourhood makes it possible to create ubiquitous city networks. Data that seem less relevant on a local and individual level might yield added value at city level, and might even provide insights on a global scale. **Create reciprocal connections in-between the personal and the collective.** In a reciprocal service, an individual benefits from providing personal information to the group if the aggregated group information returns a surplus value for his personal use and goal. In such kinds of crowd intelligence, one can feel connected with a group of others. **Combine dynamic sensor data and user generated data with static data (statistics, geo data, open data, etc.).** By connecting different kinds of data sources, it becomes feasible to combine static data, gathered through traditional research methods (e.g., periodical questionnaires), with continuous streams of user generated and sensor data. Data generated by citizens can result in high-density grids of city information that would not have been possible with traditional methods only. Citizens as well as public servants can profit from these additional information sources. **Bring about intelligence through prediction and/or anticipation.** When vast amounts of data on city phenomena are gathered, historical analysis of this data makes it possible to predict what phenomena may be expected in the future. Algorithms can be built to predict and signal these situations so people can act upon these signals. On top of that, when people have open access to the data that are collected as a crowd, people may even act upon what to be expected before systems algorithms warnings.

### 4.2 Make It Social

**Make people experience meaning by empowering them to strive for what they value in life (human values).** Many smart city applications help people out with guiding them to the fastest routes, the most efficient ways to buy products, or to monitor energy usage in the home. However, those are typically not end goals in people's lives. People might experience meaningful relevance from applications if those account for their human values, for instance feeling connected to a family, enjoying achievements, or by contributing to a cleaner planet. **Balance one's individual meaningful experience with the (organisational) concerns of other stakeholders.** Although organisational services (either provided by governments or companies) try



to target people's needs, organisational goals and constraints may not be exactly inline with people's concerns. Not always do both the organisation and the individual user experience the service as relevant. The application of pervasive technology in the city currently demands and enforces a change in the relationship between governments and citizens. Interestingly, the transformation society along with budgetary pressures pose challenges for governments that are already affecting this relation between government and citizens, and actually enabling citizens to inform city government with issues in the city, contrarily to the classic situations in which the government serve citizens by informing them on city issues. **Enrich people's environment to blend physical and digital elements into hybrid places.** City planners have mainly focussed on physical features of areas in the city, where now digital elements are becoming an integrated part of the citizen's experience of the city. Modern ways of city planning make room for an approach in which the city is envisioned as a hybrid place. What's interesting here is that the control over the digital layer in the city is not solely at the locus of public servants, but that it offers opportunities to have citizens decide themselves, even on individual level, what digital information they like to include in their view on the city, or even 'make their city'. **Expand the experience over time and space.** The pervasiveness of internet access throughout the city makes it possible to let data flow continuously from different locations at different times of the day, resulting in vast amounts of data that can be used to monitor the city in real-time, to use it for retrospective insights and to inform and guide future actions and interactions. People will be able to inform themselves on what's happening in the city at any time and any place. Also, the breadth and duration of city interactions that take place at a certain time at a certain place, can be strengthened: the connectedness of people and the data that results from interactions can be used to endure the experience later on and at other locations.

### 4.3 Make It for City Life

**Encourage value creation by people for people in the city.** The more people get connected to each other and generate data together to gain insights in their concerns, the more people can empower themselves by exchanging information, knowledge, time, products or anything else without interference of governments or companies. The opportunity for alternative ways of value creation is growing. People then become less dependent from institutions or companies to consume services that fulfil their needs. **Make the city as a whole attractive for living and working.** Although urbanisation makes cities grow, feelings of well-being do not necessarily grow accordingly. For the city of Rotterdam, the 'flight' of higher educated young professionals to other cities is a threat for the cultural diversity and for the economic prosperity of the city. By improving the city experience with the use of pervasive technologies, the city can become more meaningful to every sort of citizen.

## 5 Conclusion and Reflection

When designing for a smart city, many challenges occur in order to integrate the aesthetic, experiential, and symbolic features into a meaningful design, which empowers people in pursuing their goals in life. We argued that space and time are important factors in the design for meaningful interactions. By describing and analysing three design cases in the city of Rotterdam, we have gained a better understanding of what aspects contribute to the design of meaningful interactions in the city. With regard to the factor space, we conclude that city space can exist out of connections between different systems from individual level (body area) to a city level (local area, wide area). These connections make it possible to let people's individual data flow from a large number of locations to one aggregated set of data that reveals new insights in city phenomena. An important issue here is reciprocity, which implies that the contributing individual immediately gets a benefit from providing his personal data. Another conclusion is that for making place out of space, it seems that not only physical presence of people and their (inter)actions are needed, but that placemaking is also changing by means of the individual use of digital information. Once people can individually control what kind of digital information of their preference is bound to certain locations, the meaningfulness of a place can become more directed to its individual visitors. We also conclude that with the increase of technology and thus 'virtual spaces', physical spaces become blended with virtual space and becomes less bound to the physical location of itself and of its visitors. With regard to the factor time, the experience people have had at a certain location at a certain time is more easily expanded over time. On the one hand, because data (photos, texts, sensor data, metadata) that is generated by the people during the event itself can be used later on in, for example, social media platforms, on the other hand, because people with one had interaction with, can easily be made an online connection to be followed in other activities. Next to that, the storage of historical data makes it possible to review what has happened in the city resulting in insights that can be used to guide future decisions and actions. From the analysis of the design cases, we learned that the locus of control of both data and applications is important. Our focus has been on the human values in the design process. Once one has control of and access to the data that are self-generated, the more one use that information for personal benefit and concerns. The reciprocity between individual contribution and the use of citizens' information at city level balances the concerns between individuals and organisations. Apart from that, people are able to interact in-between using pervasive technologies without interference of organisations, to create value for each other. Here, the symbolic features of the design are crucial: do those depend on the intentions of governments and companies or can the design be open enough for citizens to load it with their values? In our future work we will aim to deepen our understanding of the role of time and space as factors in the design process of meaningful interactions in which designers have focus on human values of people that want to become social and smart citizens of their own city.

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