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Preface

Digital and interactive technologies are becoming increasingly embedded in everyday lives of people around the world. Application of technologies such as real-time, context-aware, and interactive technologies; augmented and immersive realities; social media; and location-based services has been particularly evident in urban environments where technological and sociocultural infrastructures enable easier deployment and adoption as compared to non-urban areas. There has been growing consumer demand for new forms of experiences and services enabled through these emerging technologies. We call this ambient media, as the media is embedded in the natural human living environment.

The 8th Semantic Ambient Media Workshop Experience (SAME) Proceedings where based on a collaboration between the SEACHI Workshop Smart Cities for Better Living with HCI and UX, which has been organized by UX Indonesia and was held in conjunction with Computers and Human-Computer Interaction (CHI) 2016 in San Jose, CA USA.

The extended versions of the workshop papers are freely available through http://www.ambientmediaassociation.org/Journal under open access by the International Ambient Media Association (iAMEA). iAMEA is hosting the international open access journal entitled "International Journal on Information Systems and Management in Creative eMedia", and the international open access series "International Series on Information Systems and Management in Creative eMedia" (see http://www.ambientmediaassociation.org).

The International Ambient Media Association (AMEA) organizes the Semantic Ambient Media (SAME) workshop series, which took place in 2008 in conjunction with ACM Multimedia 2008 in Vancouver, Canada; in 2009 in conjunction with AmI 2009 in Salzburg, Austria; in 2010 in conjunction with AmI 2010 in Malaga, Spain; in 2011 in conjunction with Communities and Technologies 2011 in Brisbane, Australia; in 2012 in conjunction with Pervasive 2012 in Newcastle, UK; and in 2013 in conjunction with C&T 2013 in Munich, Germany; and in 2014 in conjunction with NordCHI 2014 in Helsinki, Finland.

The workshop organizers present you a fascinating crossover of latest cutting edge views on the topic of ambient media, and hope you will be enjoying the reading. We also would like to thank all the contributors, as only with their enthusiasm the workshop can become a success. At least we would like to thank the lovely organizing team of CHI 2016, the SEACHI 2016 organisers, and our programme committee members.

The Editors

San Jose, Califorinia, USA 2016

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Concept of Interactive Machine Learning in Urban Design Problems

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ABSTRACT
This work presents a concept of interactive machine learning in a human design process. An urban design problem is viewed as a multiple-criteria optimization problem. The outlined feature of an urban design problem is the dependence of a design goal on a context of the problem. We model the design goal as a randomized fitness measure that depends on the context. In terms of multiple-criteria decision analysis (MCDA), the defined measure corresponds to a subjective expected utility of a user.

In the first stage of the proposed approach we let the algorithm explore a design space using clustering techniques. The second stage is an interactive design loop; the user makes a proposal, then the program optimizes it, gets the user's feedback and returns back the control over the application interface.

ACM Classification Keywords
D.2.2 Design Tools and Techniques: User interfaces; H.3.3 Information Search and Retrieval: Selection process; H.5.2 User Interfaces: Interaction styles; J.6 Computer-aided engineering: Computer-aided design (CAD)

Author Keywords
MCDM; interactive machine learning; urban design; multiple-criteria optimization

INTRODUCTION
Urban design decisions greatly affect the life of a city in many perspectives: the transportation network and the appearance are straightforward examples, but implications of the design go deeper into the citizens' experience. The effects of certain design decisions are not well-studied due to the complexity of the problem. Therefore, when working on urban design projects, it is common to decompose the problem into multiple aspects. Designers typically draw on past experience when subjectively prioritizing which aspects to consider with which degree of importance for their design concepts. The proposed project intends to aggregate the designers' past experience using data analysis techniques and optimization algorithms. This allows us to develop a planning support system that can help in the search for the best compromises for complex design problems.

The first challenge of a planning support system is formulating the problem: the designer's often vague qualitative requirements need to be translated into a precisely quantifiable criterion representation that can then be used in an optimization or generative algorithm. The second challenge is the fact that the priorities over the criteria depend on many factors varying with the context of the project and the designer's background: the set of good solutions may be too large and difficult to analyse, thus the program must model the context to narrow down the search domain.

This research presents a concept of interactive machine learning in an urban design context. The overall intention of the research is to improve task-related performance of the designers working with their software. Unfortunately, the nature of the application domain makes it difficult to evaluate the impact of a program on a designer's performance. One of the key performance factors in this area is the creativity of a designer. It has been argued that computer interface should be appealing, intelligent, and stimulating to endorse the creativity of an application's user[22] – thus an application is not allowed to disturb a designer focused on their work by asking too many questions in an active machine learning style. Avital and Te'Eni[2] build the concept of generativity which relates to the ability to create something new. According to Avital, two components of a task-related performance are the operational efficiency and the generative capacity; we aim at endorsing the generativity by proposing machine-generated design alternatives while trying keep the operational efficiency on a similar level with convenient CAD systems.

The goal of the research is to develop an algorithm that seamlessly integrates machine-generated design proposals into a human design process and is guided by a user's feedback. The core of the concept is a likelihood model of a designer's goals and preferences in a design session. The model is updated in a reinforcement learning loop using a human designer's feedback. The feedback comes in a binary form of design comparisons during a designer's work session. Using the maximum likelihood estimation (MLE) method in this model we construct a preference vector for a multiple-criteria design problem (MCDP) that arises in a human design. The preference vector allows reducing the design generation task to a single-criteria optimization problem. Arranged into a continuous cycle with a user design session, a program lets a user and a machine iteratively work on a same design problem proposing alternatives and optimizing them towards changing user needs.

This paper describes an ongoing research. We overview the latest findings in adjacent disciplines, explain the model and an experiment setup. We present the intermediate results on a simplified test case; however, it is difficult to evaluate performance of the approach to this date.

BACKGROUND

The approach we propose relies on techniques from different fields of research. Although Avital and Te'Eni mainly focus on the generative fit of a program, referring to Frazer[7] and Janssen[11], they view artificial intelligence and other types of smart agents as a source for creativity[2]. Incorporating certain generative design (GD) algorithms, a program can inspire or challenge a designer by creating unique design alternatives[11]. Therefore, GD is one of the aspects we need to consider in our research. Singh and Gu [23] give a comprehensive overview of common GD methods, among which are: shape grammars, L-systems, cellular automata, swarm intelligence, and evolutionary algorithms.

Evaluation methods.

Evaluation of a solution (design) is an important part of design space exploration or optimization. The key concept within the scope of the paper is the design criteria that can be made explicit. Based on these criteria a user (designer) or a program can choose a preferable solution among available alternatives.

Quantifiable design criteria for urban design tasks include purely geometrical or topological measures, such as the length of roads or space accessibility[25], as well as social aspects, especially the perception of space, e.g. streetscape security[17]. We do not restrict the way the criteria are estimated; we state explicitly that the qualitative or subjective nature of some underlying aspects introduces an uncertainty into the evaluated criteria.

A popular group of methods for evaluation of an urban district form is called Space Syntax. It has first been conceived by Hillier and Hanson[10]. Space Syntax focuses on topological properties of a space like isovists (visible space from a point[4]), axial[25] or convex[19] open space. Besides special methods like Space Syntax, depending on a stage of planning or evaluation, one may use various direct statistical quantities: length of roads, area of recreational (and other) zones, amount of different types of facilities, etc. Some microclimate phenomena and their effects on the energy performance of buildings may be estimated using simulation methods. For example, high density urban areas feature increased temperatures due to the urban heat island effect[1]. Controlling a district morphology can help to mitigate this effect[21]. Surveys are used for evaluating social metrics of existing places. Salesses et al.[20] use high throughput internet surveys for evaluating perception of a city by the citizens.

Optimization methods.

Obviously, criteria formed by the evaluation methods are interdependent and sometimes contradictory. Thus, the designer faces a complex multiple-criteria design problem (MCDP) and wants to find the best compromises between the criteria. An approach to a MCDP that is widely used in parametric design is the exploration of Pareto-optimal solutions[27, 16]. The decision as to which of the Pareto-optimal solutions is best suited for a particular problem depends on qualitative criteria or non-operational human preferences. The concept of Pareto-front in GD is used in conjugation with evolutionary algorithms (EAs): these optimization algorithms allow a user to explore Pareto-optimal subsets of generated design proposals[11, 7, 14].

Although exploration of the Pareto-optimal solutions is a feasible approach to multiple criteria optimization, in urban planning and design it has two drawbacks: first, the Pareto front may be too large for being analyzed by a human; second, the desired solution might be far away from the optimal set in a solution space, because the designer may consciously sacrifice the optimality of some aspects for others. One way to find a desirable solution is to estimate the designer's priorities over the design criteria. This problem lies in the area of multiple-criteria decision making (MCDM) [13]. MCDM methods vary in a way they relate criteria to each other. The simplest approach is to make a single utility function as a linear combination of criteria; then the problem reduces to a search of weights (importance) for each criterion. This approach has a number of extensions that treat the weights, for example, as probabilities of being the most important criterion [18]. Many sociological studies argue that people tend to underestimate low probabilities [18, 13], thus more recent developments introduce uncertain methods and the fuzzy logic to utility models (e.g. [3]).

Data analysis.

There is no such a single measure to evaluate explicitly the quality of an urban district; and it is not clear how to asses the citizens' perception of a city in an absolute scale. Thus, one cannot ask a person to assess the quality directly. However, people are good at comparing and selecting: given a number of alternatives, a person could easily answer simple questions, like "where would you prefer to live?", or "which of these places looks more friendly?". They also can assign grades (labels, such as "good", "excellent", "bad", etc.), which then may be used in various learning-to-rank algorithms. The techniques of using these user assessments rapidly developed over the last decades due to the rising demand for them in data mining, information retrieval, and natural language processing[15, 26].

Salesses et al. [20] did crowd sourcing to gather pairwise comparisons of the images of four cities in the USA and Austria. They used the obtained data to score the streetscapes according to three different measures: class, safety, and uniqueness. This enabled them to correlate the scores with some measurable characteristics, such as income, population, or number of homicides. They found that the perception scores were able to reflect the information about urban environment, which was not fully described by the income-based measures.

A recent research at MIT Media Lab [17] put further the ideas of P. Salesses. They showed the possibility to measure some aspects of human perception at high precision on a map[1] by using comparison data, image recognition, and machine learning techniques. The authors of the Streetscore algorithm used Salesses' dataset consisted of 208738 pairwise comparisons of streetscape images answering the question "Which place looks safer?". Then they ranked the images in the sample using the Microsoft TrueSkill algorithm [9] and evaluated the predictive power of various image features on the constructed score. Finally, they used the developed algorithm on a large number of images from Google Street View to make a high-precision map of the perceived street safety.

The Streetscore research is an example of a way to develop a design criterion that reflects social performance of an urban area. The key role in this approach is played by the TrueSkill scoring algorithm that allows constructing a rating of the elements in a data sample according to their pairwise comparisons. TrueSkill is a generalization of the Elo rating system; other modifications exist that have proven to be effective for scoring [24].

APPROACH

Interactive design process

The research does not aim at providing fully machine-generated urban design proposals. Instead, we want to develop a recommendation system that could be integrated into a design process conducted by a human. Figure 1 presents a UML diagram of the proposed machine learning and user interaction process. Process A shows the interaction:

- A.1 A designer creates the first version of a design.
- A.2 The program analyzes the design assuming it to be preferable for the designer. This allows making a hypothesis on the design goals.
- A.3 According to the created (machine) model of the designer's goals, the program suggests a small set of the machine-generated alternatives.
- A.4 The designer chooses one of the alternatives, thus giving additional information for refining the machine's model.
- A.5.1 The designer finishes the work, or continues to step A.1 creating a new design version.

On each iteration the designer submits a new design version; the program assumes it is better than a previous version – this gives more information for the machine's model of the designer's preferences.

The interaction cycle described above does not require providing any information besides the input it takes by observing a standard human design process: the only additional action the designer does is selecting the preferred solution among the proposed ones, which is itself the reason to use the application and the aim of the project. This setup can be viewed as a reinforcement learning model with human reward, which is a rapidly developing topic in machine learning (similar models are described in e.g. [5, 12]).

Modelling data and features.

Let $X \in \Omega$ be a design descriptor - a random object in an arbitrary domain. In case of urban design X represents a single district layout, but it is not important in context of the described model. A (design) criterion is any numeric-valued function defined on a layout space. We assume aggregating output of this function into one or several values per layout. Then we consider m criteria $g_j(X) \in \mathbb{R}$. Or, the same: $\mathbf{g} : \Omega \to \mathbb{R}^m$.

Let $\mu_j = \mathrm{E}g_j(X)$, and $\sigma_j = \sqrt{\mathrm{Var}g_j(X)}$. Then define a set of normalized criteria by applying standard normal distribution function:

$$j \in 1..m, \qquad f_j(X) = \Phi\left(\frac{g_j(X) - \mu_j}{\sigma_j}\right), \qquad f_j(X) \in (0,1). \tag{1}$$

This gives a set of criteria functions that all lie in an interval $(0,1)$ and differ only in shape: $\mathbf{f} : \Omega \to (0,1)^m$, or in a shorter notation $\mathbf{f}(X^i) = \mathbf{f}^i \in (0,1)^m$. Given a data set containing n points, criteria values $\mathbf{f}$ become a matrix $F = \{f_{ij}\}_{ij}^{nm} \in (0,1)^{n \times m}$.

Next, we assume that a designer wants to optimize the layout according to the set of criteria. Hence, one implicitly has a desired value $y_j \in [0,1]$ for each criterion. Applying normal distribution function to the criteria allows treating in the same way the tasks of maximizing ($y_j = 1$), minimizing ($y_j = 0$), or converging to a particular value by setting appropriate y_j. A shorter notation is $\mathbf{y} \in [0,1]^m$.

By means of using the designer interaction described on Figure 1 process A, a designer provides the relational information in the form of designs and an answer to question (A.4): is one design better than another one according to the design requirements and the designer preferences?

We introduce a notion of an abstract quality of an urban design, that has no absolute measure, but rather is defined implicitly according to the relational data described above, and thus dependent on a particular designer and their design process. We combine the criteria into a single urban design quality measure using a preference weights vector. In MCDM this measure is referred as a (subjective) expected utility. Given a design goal – a vector of reference values $\mathbf{y}$, we use a goal programming utility function:

$$\theta(X) = \sum_{j=1}^{m} c_j (f_j(X) - y_j)^2. \tag{2}$$

Here c_j is a weight assigned to a criteria (i.e. preference). In a vector form: $\mathbf{c} \in [0,1]^m$. In order not to get degenerate fitness measure, we put constraints on the weights $\sum_{j=1}^{m} c_j = 1$. Given these constraints, the model has $2m - 1$ degrees of freedom (m for $\mathbf{y}$ and $(m-1)$ for $\mathbf{c}$). Utility function $\theta(X)$ measures how far the layout X is from the designer's ideal.

[1] http://streetscore.media.mit.edu/

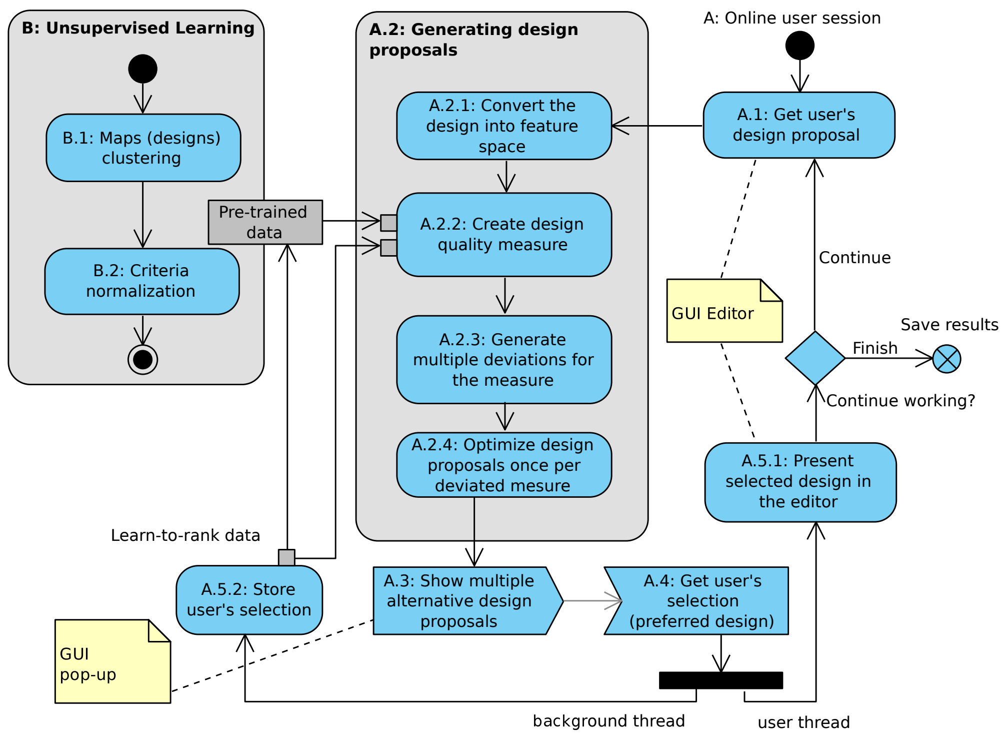


Figure 1: Learning cycle embedded into a design process

Because of the designer's feedback data, the preference vector helps to represent the quality measure rather as a reflection of the designer preferences (for a concrete design task) than as a fixed function. The creation of the preference vector for the design session is depicted as a step A.2.2 on Figure 1. Once the preference vector is known for a particular design type, the program can suggest the designer an alternative solution (A.3) by optimizing designer-created proposals according to certain quality measures (i.e. fitness function) (A.2.4). By modifying the preference vector, one can achieve the same effect as does the mutation procedure in genetic algorithms, hence introducing discrepancy into the possible solutions. This is to be done at step A.2.3 of the user interaction process. Note, the approach proposes to alter the fitness function instead of the generated solution; the solutions obtained by optimization according to different fitness functions are expected to vary, yet being optimal with respect to their measures.

Feedback

Given the problem statement, the information we can get from the user is *relative*, i.e. binary outcome for two layouts X^{i_1}, X^{i_2} whether one layout is better than another. In addition, user's feedback is highly subjective - a user may be uncertain whether one layout is better than another. We represent this uncertainty via random component - error, which results in a following model of layout performance:

$$p_i = -\theta(X^i) + \sqrt{2}s\xi_i, \qquad s > 0, \qquad \xi_i \sim \mathcal{N}(0,1). \quad (3)$$

Note the negative sign of θ: p_i represents performance of the layout – we model it as randomized negative of the bias 2. Then the feedback of a user is represented as follows:

$$\delta_i = \begin{cases} -1 & p_{i_1} - p_{i_2} < 0, \\ 1 & p_{i_1} - p_{i_2} \geq 0. \end{cases} \quad (4)$$

Here $\delta_i = 1$ means that the user has chosen X^{i_1} and $\delta_i = -1$ means that the user has chosen X^{i_2}. δ is a random variable that is fully determined by random variables p_1 and p_2 (and by X if one models X as a random variable). Therefore, one can compute the distribution of the feedback δ_i:

$$\Pr(\delta_i = 1 | X^{i_1}, X^{i_2}) = \Pr\left(\frac{\theta(X^{i_2}) - \theta(X^{i_1})}{2s} \geq \xi_i \,\middle|\, X^{i_1}, X^{i_2}\right).$$

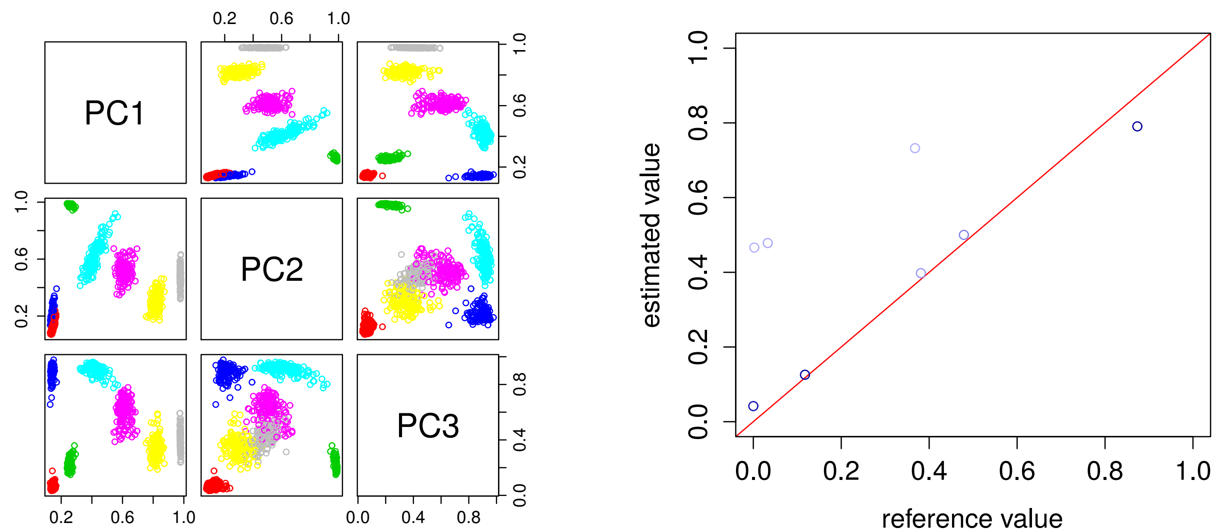
Let $a_{ij} = f_{i_2 j} - f_{i_1 j}$ and $b_{ij} = \frac{1}{2}(f_{i_1 j} + f_{i_2 j})$. Note, that in general they are strongly dependent as random variables and fully determined by X^{i_1}, X^{i_2}; $\{a_{ij}\} = A \in (-1,1)^{n\times m}$ and $\{b_{ij}\} = B \in (0,1)^{n\times m}$. Then the distribution of δ_i is defined as follows:

$$\Pr(\delta_i | a_{ij}, b_{ij}) = \Phi\left(\frac{\delta_i}{s}\sum_{j=1}^{m} c_j a_{ij}(b_{ij} - y_j)\right). \quad (5)$$

Matrices A and B, and vector δ are available in the dataset and $s, \mathbf{c}, \mathbf{y}$ are to be estimated. To simplify equation 5, we introduce a new variable $r_{ij} = \delta_i a_{ij}$, fully determined by the original variables; $\{r_{ij}\} = R \in (-1,1)^{n\times m}$. As a result, we get the final formula for a distribution of a user's decisioin δ_i:

$$\Pr(\delta_i | r_{ij}, b_{ij}) = \Phi\left(\frac{1}{s}\sum_{j=1}^{m} c_j r_{ij}(b_{ij} - y_j)\right). \quad (6)$$

Note, that $r_{ij} < 0$ when and only when the user feedback is "wrong", because then the utility difference $(\theta(X^{i_1}) - \theta(X^{i_2}))$



(a) Pair plots of the first three principal components of a point shape feature space. The points are coloured according to pre-defined shapes. The clusters are easily distinguishable.

(b) A biplot of estimating user preferences for one of the clusters. The more important (according to preference weights **c**) goals **y** are, the closer they are to reference values (the darker points).

Figure 2: Clusters of similar point shapes and a preference estimation for one of them.

and δ_i have different signs. A fraction of positive r_{ij} in available data may be a good measure of a problem difficulty.

Likelihood function.
Equation 6 allows estimating likelihood of the fitness measure parameters **c**, **y**, and model error parameter s: by adjusting these parameters one maximizes the span between $\theta(X^{i_1})$ and $\theta(X^{i_2})$, which increases the probability of getting "correct" δ_i. Now one can construct log-likelihood function:

$$\hat{l}(s, \mathbf{c}, \mathbf{y} | R, B) = \frac{1}{n} \sum_{i=1}^{n} \log \left[\Phi \left(\frac{1}{s} \sum_{j=1}^{m} c_j r_{ij} (b_{ij} - y_j) \right) \right]. \quad (7)$$

Intuitively, equation 7 expresses the likelihood of parameters s, c_j, y_j given the dependence of the feedback δ_i on the sample a_{ij}, b_{ij}. By maximizing $\hat{l}$ one can find optimal values for parameters s, c_j, y_j. Considering $c_m = 1 - \sum_{j=1}^{m-1} c_j$, this model has $2m$ degrees of freedom, where m is a dimensionality of a criteria vector.

Learning model

Unsupervised phase
Process B on Figure 1 describes the unsupervised part of the machine learning process. As an initial dataset for the unsupervised learning we can use existing spatial configurations, which are freely available through OpenStreetMap. That is, we have an initial data sample $X_0 = x_1, ..x_{n_0}$ in a design space Ω, and a corresponding matrix of features (criteria) $F(X_0) = F_0 \in (0,1)^{n_0 \times m}$.

In the presented research we assume reference values **y** to implicitly depend on layout X. On unsupervised learning stage, however, we do not have an access to any designer's data to asses this dependence. Instead, we have a feature matrix F_0 that helps to infer a structure of the feature space: we use clustering techniques to group layouts X by their similarity in the feature space. For clustering layouts we use `R` implementation `mclust` of the expectation maximization algorithm by Fraley et al [6].

Classification
Unsupervised phase of the learning labels initial data, but after that any new data must be classified into one of the available clusters. This can be done by a variety of supervised learning methods; we use k-nearest neighbours algorithm implemented by Hechenbichler and Schliep in `R` package `kknn` [8], because it allows fast incremental classification during online phase, when new data points come one at a time.

Preference estimation
Once we have a label assigned to a particular design layout X_i, we can assume that design goal **y** does not change a lot within an assigned cluster. Thus we optimize a likelihood function 7 on a data subset from this cluster to estimate preference parameters of a designer in a given case. According to the proposed interaction scheme 3.1, the data that the algorithm gets on each iteration is a pair of layouts X^{i_1}, X^{i_2} and a decision feedback δ_i.

One problem in this setting is that we have to start with no data. To address this, we allow for training period, when the algorithm only analyses a user's actions. If there was a similar session (related to the same feature cluster), data from that session can act as a pre-training set.

Another problem is that layouts X^{i_1}, X^{i_2} might be on the "edge" between two clusters, or they, together with feedback δ_i, may contradict to other feedback in the cluster. These are addressed by adding a following heuristic to the classification phase: the data for preference estimation is taken only for those clusters, preference directions for which are closer to the direction of a given layouts-feedback triple.

Layout optimization

The layout optimization is the final phase of the layout generation. The last layout X submitted by a user is optimized according to utility function 2, formed during the interactive design session, with a preference vector found by the previous phases of the algorithm. One can use convenient optimization algorithms for this phase. The major caveat here is that success of the optimization is highly dependent on the structure of the layout space Ω and its mapping on the features F.

SIMPLIFIED TEST CASE

The proposed concept is implemented on a toy design case of shaping a small set of points. A user is asked to form various patterns consisting of eight points, moving one point at a time using a mouse in a simple graphical interface. By pressing space bar on a keyboard, the user indicates design submissions, giving the program a necessary feedback. The feature (criteria) space for the problem is formed from all pairwise distances between points sorted in increasing order, plus additional statistical properties of a point set. After applying principal component decomposition, this feature set is invariant to points re-numeration, rotation, scale and shift.

Prior to the experiment with a human designer we create pretraining data for clustering by generating seven simple shapes with Gaussian noise and varying parameters: ellipse, parallel lines, rectangle, cross, T-shape, corner, single line. Figure 2a presents pair plots of three most significant principal components. Points on the figure are coloured according to the shape types. This figure shows that the constructed feature space is expressive enough to distinguish common layout types. Indeed, the clusters are visually separable.

Figure 2b presents the results of maximum likelihood estimation (maximizing function 7) applied on one of the clusters in the generated dataset (a user arranges the points in a rectangular-like shape). The plot compares the criteria values $\mathbf{f}_{\text{ref}}$ at a reference layout point X_{ref} (reference shape) to estimated goal values $\mathbf{y}$. The color intensity of a point y_i depicts the preference weight c_i of that point: the more importance the algorithm assigns to a point, the darker it is. Clearly, the optimization algorithm is better at estimating values of criteria that are more important due to the structure of the utility function 2.

DATA ACQUISITION AND SOFTWARE PROTOTYPE

In order to proceed with real design cases, we need to get data from close-to-real design problems. The main case study of a project is a reorganization of a small informal settlement in Cape Town. The level of details is restricted to a size of a single district and does not allow changes of building facades. A well-defined design problem on a given case study makes possible to list and discuss with designers their most important design considerations. Should the our approach prove its efficiency on the given case, it can be extended further to more general design problems.

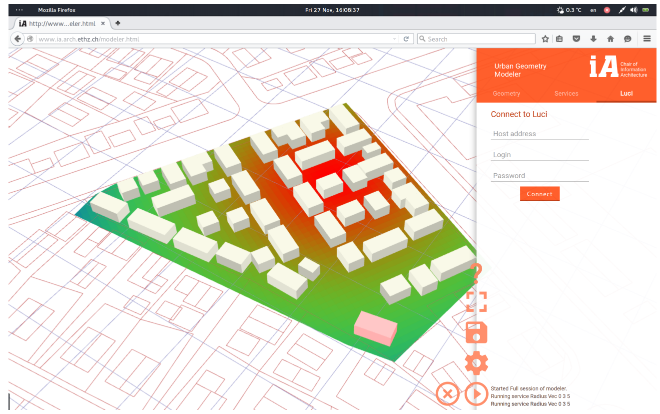


Figure 3: Qua-view is a front-end of qua-kit running in a browser.

To get enough data for the research we develop a simple web-tool called Quick Urban Analysis Kit (qua-kit) that is capable of editing geometry and visualizing computational analysis results. The tool is developed open-source at github.com[2]. Figure 3 presents a screenshot of qua-view – a front-end part of the tool running in a web browser. Qua-view is to be exposed to a wide audience, such as students of massive open online courses (MOOCs). The chair of Information Architecture at ETH Zürich develops several MOOCs on edX platform [3]. We create a set of exercises for students of these courses using the tool, so it serves two purposes: on the one hand, it provides an interactive learning environment for students, and, on the other hand, it gives us necessary feedback data to train the model and test the approach. The exercises are available online[4].

CONCLUSIONS AND FURTHER RESEARCH

The core ideas of the approach are the declaration of the data sources and the communication loop between a user and a program. We have developed the learning model based on changes to designs submitted by the user. This approach resembles a reinforcement learning model with human reward, which is a rapidly developing topic in machine learning (such models are described in e.g. [12]). We have also mentioned that the program may propose multiple design alternatives (Figure 1 A.3). Since the program can control generation of the alternatives, it can use active learning exploration-exploitation approach to improve its estimates. This reveals a lot of opportunities for further research.

A designer's priorities usually change during the design session as their proposal advances, hence a design session can also be modelled, for instance, as Markov decision process.

At the current stage of the project we are working on simplified geometries. Moving to real-world districts is a principle step towards completion of the project, and is to be done in near future.

[2] `https://github.com/achirkin/qua-kit`
[3] `https://www.edx.org/xseries/future-cities`
[4] `https://qua-kit.ethz.ch/`

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Tackling Challenges in the Engagement of Citizens with Smart City Initiatives

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ABSTRACT
Smart City (SC) initiatives offer best possible outcomes to citizens and other stakeholders when those people are involved centrally in all stages of the project. However, undertaking design processes that facilitate citizen engagement often involves prohibitive challenges in cost, design and deployment mechanisms, particularly for small cities that have limited resources. We report on a project carried out in Cork City, a small city in Ireland, where a method inspired by *crowdsourcing* was used to involve local participants in decisions regarding smart city infrastructure. Academics, local government, volunteers and civil organisations came together to collaboratively design and carry out a study to represent local interests around the deployment of smart city infrastructure. Our project demonstrates a new way of translating crowdsourcing for use in government problem-solving. It was comparatively inexpensive, creative in design, and flexible but collaborative in deployment, resulting in high volume of reliable data for project prioritisation and implementation.

Author Keywords
Smart cities; engagement; participation; crowdsourcing

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
The Smart City (SC) is a new urban management practice using information and communication technologies to boost cities' competitiveness, promote sustainable development, and enhance the quality of life of citizens/residents. Such initiatives frequently involve the building of infrastructures and procedures for sharing and integration of data between public service departments, and between public and private sectors, in order to improve the quality and resolution of decision making about city services and development.

While there are many elements underpinning successful implementation of SC initiatives and/or programmes, resident engagement and participation appear to be critical success factors for those programmes [13]. Resident engagement refers to the process of informing residents, getting them excited, and their subsequent participation in decisions from early stage of design to implementation and expansion [6]. However, each of these activities involve costs in both time and money, and are frequently beyond the means of small cities. Indeed, large cities frequently hire consulting companies to carry out this work, or assign a full time in-house team. In order for small cities to engender the same levels of participation, more creative methods must be developed.

In this paper we describe a project in which academics, local government, volunteers and civil organisations came together to collaboratively design and carry out a study to represent local interests around the deployment of smart city infrastructure. We first provide a brief introduction to smart cities, and current scholarship on the importance of community participation and engagement with such projects. We present crowdsourcing as a method that can provide inspiration for the design of low cost smart city data gathering projects. We report on the process of carrying out and managing a crowdsourcing-inspired smart city project in Cork City, a small city in Ireland and present some initial results regarding the implementation of this project.

BACKGROUND
Early Smart City projects have aimed to address urban challenges including traffic congestion; energy services; housing allocation and development; food supply; noise and air pollution; water supply; waste water treatment and social disparities [4]. Typically, these projects involve the use of IT services to share and integrate data coming from different sources relevant to the city, in order to improve the quality of decision making. Often, data visualisation is a key part of this process. Increasingly, citizen consultation and participation is also seen as a necessary part of this process.

Citizen Participation and Engagement

The European Union (EU) emphasises the importance of citizen engagement in SC projects, to empower EU citizens at the local level, to improve success rates and foster citizen ownership of programmes [15] and to improve quality of life for citizens. It is considered that residents' engagement will more readily invite residents within the project boundaries to become strong advocates for the project.

More generally, there has also been a growing recognition in recent years of the importance of collaboration and dialogue between design teams and stakeholders at all stages (design, development, testing, implementation, evaluation) of projects that have the potential to affect those stakeholders [20]. This is the case with SC projects, but also in any context where IT is introduced in order to improve services, from work design [7] to mental health services [9]. The practice of designing products and services in close collaboration with potential users is referred to as Participatory Design.

Research is also increasing in an area called "digital civics", which aims to understand how technology can be used to promote and improve community participation, political engagement and democracy [14]. For example, projects have examined how data can be gathered [18] and displayed [11] on a hyper-local scale to improve participation in local decision making. Research in this area often follows participatory design principles, where the community is encouraged to not only engage in dialogue with designers, but to drive decisions about how technology is designed and implemented [21].

In contrast with the participatory community focused design studies mentioned above, it is often the case that existing SC initiatives focus on technology testing rather than directly addressing practical and immediate problems with the information infrastructure of a city. While these studies aim to prove that certain technologies could work in real world and scaled-up settings, such an approach rarely takes advantage at the outset of the potential contribution of resident engagement in ensuring the success of initiatives when real-time adoption of the solutions is proposed [8].

In its pursuit of SC initiatives, Cork City faced a challenge in how to effectively engage with its residents and involve them in consultation, feedback, decision-making, and implementation processes. The decision was made to pursue a strategy, inspired by crowdsourcing, in order to best make use of local expertise, collaborating with academics, industry and social organisations to resolve the challenges.

Crowdsourcing

Crowdsourcing refers to a method of gathering and/or analysing data that is led by non-experts. It is used in situations where the amount of data that must be dealt with is so large that it is not feasible or economical to employ experts, but which the task also cannot feasibly be automated. It has been used successfully in many different areas, for example, gathering of data on habitats of insects and animals [16], classifying high fidelity photos of deep space [19], and DNA analysis [10].

Researchers that have successfully used crowdsourcing to gather useful and valid data emphasise the importance of designing and managing the process through which data is gathered. People will engage willingly and usefully in crowdsourcing if the task assigned to them is simple and clear, and they can see how their work is contributing to science [19].

METHOD

Participation through Crowdsourcing

In the Cork Smart City project, we needed high fidelity information, from a breadth of city residents, but had very little budget. We adopted a data collection method inspired by crowdsourcing, in which interested local academics, industry, volunteers and social organisations collaborated in the study design and data collection. The strategy followed formal guidance to define and design relevant indicators for resident engagement, sample data, and experiments [1].

The guidance included step-by-step tutorial to put the selected crowds to work for specific tasks.

The first step was defining overall aims of the project with actionable objectives. This also involved the defining and designing exercises of what to assess in citizens/residents engagement in this data collection stage. Apart from literature review in citizen participation and engagement, the project had the opportunities to incorporate inputs from relevant experts and practitioners. After series of discussions and critical reviews, the project was approved to measure initial three key aspects of public participation, digital skills, and public infrastructure access and usage. An additional aspect was the regular updated demographical data. The three aspects comprised of ten indicators, which were later on measured by 20 questions in a questionnaire.

The second step was designing the questionnaire and calculating samples. This was a crucial stage for the project to get the right expertise from its crowd. The Managing the crowd section below describes the expertise involved and what they would benefit from the project.

The third step was designing the survey deployment strategies. The project aimed at collecting a holistic picture of Cork's citizens/residents, including children, seniors, local authorities, and general public, therefore, multiple strategies were employed according to the project's crowd capabilities and authorities. For instance, city and county were responsible for the survey targeting local authorities via an online survey to be sent through their email systems. Clarification of this step is in the below section of Facts to Formation.

The fourth step was running the survey research. The deployment plans were in place including specific time frames for each of the survey sets. Access channels to potential survey respondents and specific names of the tasks' champions from the crowd were provided to the involved people. This ensured transparency and authorities of the project, helping each participants to be sure about their parts in a complete picture of the project.

The fifth and final step was collecting data and analysing results. The data collection task in this project varied because of the different deployment strategies. The data from most representative sample of general public were collected using student volunteers. More on this can be found in the following section of Managing the crowd.

Quality control was employed throughout the second step to the final stage of analysing results. The quality control for the questionnaire design, for example, was reviewed with experts, through pilot testing (twice for the survey targeting the general public), and continuous inputs from early survey respondents.

Facts to Formation

Prior to the project's formation, it was necessary to understand who are we working with, what are the resources we can access, how are we going to make the project relevant to those who would involve, impact, and benefit from it. All of those facts would have affected to costs, design, and deployment mechanism of the project. The crowdsourcing action rules [1] provide guiding principles for the project formation with crucial considerations including picking the right crowdsourcing model, picking the right crowd, offering incentives, and identifying decision makers. The lead researcher analysed the rules and decided that the project should be a combination crowdsourcing model, which included a collective intelligent/crowd wisdom [17], a crowd creation, and a crowd funding model. The decision came natural because of the project's stakeholders, their demands, and commitments as described in the Managing the crowd section below. This was where the project got to be innovative in the way it picked the right crowd. The stakeholder exercise arose with specific actions including cultivating, stewarding, sustaining, and requiring interactive participation of the each and every stakeholders in the selected crowd. Other action rules were explained in more details in the Managing the crowd section.

First, the lead researcher looked at the establishment and initiators of the Cork Smart Gateway: The initiative was originated by four key institutions of City Council, County Council, NIMBUS (a technology centre) in Cork Institute of Technology, and Tyndall National Institute, a technology research hub in University College Cork (UCC). These are established organisations with authorities, international reputations, and local familiarity. Therefore, the project should utilise those formal channels in accessing its target audience (i.e. survey respondents), in sharing and sponsoring of responsibilities, whether it's financial or non-financial contributions.

Besides the upfront and ongoing commitments, the key initiators also have their wider expertise resource and networks that the project can tap in. These factors allowed the project to follow a combination crowdsourcing model, which includes collective intelligent (crowd wisdom), crowd creation, and crowdfunding. The project's framework was shaped with a projection of high success chance for reaching and engaging many people that resulted in good turn-out of survey respondents. The projection would work if the deployment methods were innovative and nimble. Since the project and its content were multi-disciplinary by design, it required lots of inputs from expertise and people familiar with subjects. A stakeholder mapping exercise came in to address the cross-cutting approach.

Managing the crowd

The crowd of the project was diverse. It involved local government, academics, citizens/residents, communities, industries, social organisation and many more (see Figure 1). They were identified and analysed to locate their shared responsibilities and interests in local context. Accordingly, the researcher engaged and sold the project to the stakeholders, offering benefits and seeking resources, access permission, and other help needed from each of the stakeholders. The stakeholders were pitched with outcomes and impacts that the project could contribute and/or compliment to their organisations or to individuals.

The stakeholder mapping was crucial prior to running the study and expertise was utilised from local academic pools and numerous practitioners. The mapping enabled the right expertise for the specific tasks, meanwhile locating expertise required homework to be done for identifying potential similar interests. The tactic worked for Cork because the presence of two universities that have dozens of relevant academics. The expertise contribution was on merit basis and mutual benefits including access and resources for future research.

The strategy also composed series of surveys to collect relevant city residents' data and produce a baseline and analysis for Cork. Survey and questionnaire designs received quality inputs from UCC experts. Another layer of crowdsourcing for survey deployment was applied: using student volunteers from UCC and Cork Institute of Technology to carry out door-to-door interviews. The involvement of the student volunteers incorporated key instructions, trainings with household interviewers from Central Statistics Office, academic credits, token incentives, and volunteering recognitions.

All of the employed tactics followed the crowdsourcing wisdoms and motivations including the opportunity to make money, the opportunity to develop skills (communication and interpersonal), the potential to leverage freelance work for students [1]. The professionals also benefitted from new approaches, networks, and recognitions within and outside their own organisations for community contributions. Other Web-based survey sets were designed to harness the greater contribution of the public. The survey distribution itself also leveraged the Web medium, email lists, and newer applications including Twitter, Facebook, and LinkedIn.

Figure 1. The Stakeholders mapping was time a consuming and challenging exercise. It required economic, political, social, and cultural understandings of the city. Layers of policies (i.e. EU, regional, national, local) enabled identification of responsibilities' boundary and overlapping or mutual areas of stakeholders, thus involving them at different tasks of the deployment plan.

FINDINGS

The crowdsourcing approach was demonstrated as a useful strategy for interested local people engage constructively with local government around important infrastructure decisions. The process of local interested experts collaboratively crafting the strategy and implementation plans, by itself, showed a new way of addressing the cost, design, and deployment challenges for effective local engagement. For instance, the informed residents would become more engaged if a relevant tool, such as a local mobile application, is available. They were asked to contribute at the beginning of the SC initiatives, they would tend to keep track on progresses. This motivation would help local authorities to sustain the public involvement not only in SC programmes but also in other public issues.

In Cork City's crowdsourced studies, the solution produced the following results to the stakeholders:

- A sizable baseline data of more than 2% of the city's total population
- Lower costs: from 3 to 10 times cheaper than using a service provider for the door-to-door survey
- Large amount of residents and citizens become aware of the Cork Smart Gateway (20K on Twitter; 14K on LinkedIn, 2K+ face-to-face; 35K+ students and universities' staff)
- Series of data-driven analysis for project prioritisation and planning
- Almost 200 trained students for household survey interviewers
- New networks of authorities, academics, practitioners, and industries for research and business collaborations

Respondents	No
Seniors	400
General Public (non-representative sample)	1000
General Public (representative sample)	950
Youth	767
Officials	352

Table 1: Five sets of surveys (25 to 30-questions) collected a holistic view of all Cork residents. The surveys were the first systematic and widespread assessment for Cork in any local development initiatives. Crowdsourcing worked for all Web-based and face-to-face surveys. What works and what do not work within each of the mediums was great learning experience.

With the inputs from 3000+ respondents in the survey sets, Cork SC initiatives can now plan for the projects that would attract business and residents' participation in their roles as service providers, users, and/or co-managers [8], [13]. This would enable the ideal form co-creation and co-delivery of SC solutions for risk sharing and co-benefitting which the SC initiatives could offer [3]. While the benefits for Cork and its stakeholders are obvious, the crowdsourcing method generated lessons learned for other cities of similar size, SC oriented, and resource-constrained like Cork. The crowdsourced strategy was at least three times cheaper than the traditional way of contracting the job to service providers. The method was also fast turnaround, high quality, and flexibility [2]. Since it's a crowdsourced strategy, key stakeholders shared financial resources at much smaller portions [12]. This enabled the strategy to move faster than other projects that hit finance thresholds. The strategy identified relevant expertise to utilise at every stage of design, planning and implementation, thus quality of each tasks received multiple professional and experienced eyes.

The employed crowdsourcing had really high flexibility in its deployment such as the recruitment of door-to-door interviewers, incentives, participation of many social and community groups [5]. This has worked particularly well in the data collection stage for the SC initiatives. It enabled local residents to learn about what's involve locally in a near future and to choose how they are going to be a part of it. This large, ambitious and successful project has raised many interesting issues that deserve further discussion at the workshop:

- Through its focus on crowdsourcing, this project demonstrates constructive, collaborative and citizen-led methods for participating in decisions around local infrastructure. This stands in contrast with the approach of many cities, which merely attempt to make decisions more acceptable to citizens.
- It gave the cities options to cope with their current challenges of cost, design and deployment mechanism for this important mission.
- Leading the crowdsourcing solution, the researcher would be able to share key findings of the surveys, their implications and usages by stakeholders. Lessons about what work and what does not work can be discussed in the stages from designing, planning, and implementing.
- The research method was employed in the SC-motivated small city, however, questions remain for the method to be used in other government problem-solving.

The crowdsourcing method proved the real values of the collective intelligence and crowd wisdom of experts and general public. It also gave the crowd a chance to validate itself from emerging trend of SC, which facilitates the crowd contributions in many more ways that didn't exist in the past.

While resident engagement and participation appeared to be critical success factors for the SC programmes, crowdsourcing can add as another solution for cities to consider responding to the fundamental question of how to effectively engage with residents and involve them in consultation, feedback, decision-making, and implementation processes.

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Squat & Grow: Designing Smart Human-Food Interactions in Singapore

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ABSTRACT
Squat & Grow was a two-week series of workshops, talks and field trips aimed to support a sustainable food culture in Singapore, and test alternative scenarios of the Smart Nation plan. The project encouraged citizens to participate and co-design an open platform organized around DIY low-cost technology and "smart" food practices. In this paper, we describe two Squat & Grow workshops run by tutors from Indonesia and Singapore, and show how the Smart Nation can be differently built through DIY biological and technological activities. We also demonstrate how Singapore becomes a conduit rather than a center for technological innovation and economic development within the region.

Author Keywords
Food; DIY; Maker; Smart Nation; Singapore; HCI

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION

Squat & Grow (S&G) was a two-week series of workshops, talks, and field trips aimed to support a sustainable food culture in Singapore, and test alternative scenarios of a smart city [13]. S&G served as a site where citizens co-designed an open platform organized around do-it-yourself (DIY) low-cost technology and "smart" food practices. In this sense, the project is a DIY response to existing smart city plans claiming to use technology to create transparent interactions between citizens and various stakeholders through Internet of Things (IoT) technology [4]. S&G specifically addressed the Singapore's Smart Nation plan that promises to "harness technology and create more opportunities for citizens to engage in participatory activities" [7]. Even though Smart Nation introduces a variety of innovative solutions, most of them are leveraged from within the government or corporate sector and consider citizens only as end users. By inviting designers, researchers, hackers, and food-tech enthusiasts from Southeast Asia region (SEA), S&G aimed to test alternative scenarios of a peer-governed Smart Nation future built directly by citizens.

The project was initiated by three Ph.D. students (including authors) and supported by local initiatives Edible Garden City Singapore, Hackerspace.sg, and OneMaker Group (OMG). During the two weeks, S&G accommodated 21 events ranging from food workshops such as fermentation and herbal medicine tutorials to maker sessions on DIY food-tech gadgets. Instead of relying on government or corporate funds, we followed a grassroots model based on a free entry and a peer-sharing of resources as well as expenses. All S&G sessions were open to the public audience that was invited to participate actively by proposing their interventions into the scheduled program.

The field of HCI has shown considerable interest in food issues such as food sustainability, safety, or security. Scholars have offered a variety of scenarios to enhance resilient food production and distribution [2,3,9], while accentuating a need for consumers' direct hands-on engagement in "everyday food science" [8]. While addressing the specific context of food sustainability in Singapore, the S&G encouraged citizens' participation in traditional as well as more experimental food practices to inspire alternative Smart Nation visions. Here, we describe two S&G workshops and show how the Smart Nation can be differently built through DIY biological and technological activities. We also demonstrate how Singapore becomes a conduit rather than a center for technological innovation within SEA, and discuss a need to dismantle the very hub-ness of Singapore for more inclusive transnational collaborations within the region.

SMART (FOOD) CITIES

The concept of smart city involves the use of ICT to transform life and working environments beneficial for the city and its citizens [4]. Thus, the inclusion of lay people in the making of a smart city is essential. However, present smart city plans mostly include lay people as mere users of ready-made solutions, and preserve the creative processes in the hands of experts and start-up intelligence [4,7]. HCI scholars have questioned such lay-expert divide that sees lay people as incapable of understanding complex or expert issues and highlighted advantages of non-experts' inclusion in social innovation processes [1,8,11].

The S&G project followed this recommendation and probed a scenario of "smart" urban future developed not only *for citizens* by also directly *by citizens* while considering expert stakeholders as a periphery to the featured decision-making processes. In this sense, we wanted to see what happens if we exclude the corporate or government-based authorities, and put a full control over the creative processes into the hands of S&G participants.

Smart city plans concerned about environmental sustainability are highly connected to issues of sustainable food production [6]. Singapore's food supply is fulfilled largely by imports (over 90%), and the local food sustainability infrastructure is still rather immature. Probably the most palpable local food issue is the food wastage, which has risen by 50% over the last decade, with 788 600 tons of food waste produced every year [14]. However, as more Singaporeans realize the negative environmental and individual health impacts of unsustainable food practices, local demand for eco-friendly food products and services increases [12]. As a result, a number of citizen-driven food sustainability initiatives such as Urban Farmers Singapore, Edible Garden City Singapore, or Seeds Exchange Sg, have emerged all over the city-state. This shift has prompted local policymakers to improve people's overall awareness of sustainable food practices, and support their active participation [9]. Singapore's Smart Nation plan can be considered as one step in these efforts.

Smart Nation Plan: Innovation and Sustainability in Singapore

Initiated by the Infocomm Development Authority of Singapore (IDA) in 2013, the Smart Nation plan represents Singapore's goals to become the first Smart Nation globally [7]. Along with the state's worries about the impact of population ageing and density on food, water, and energy resources, the initiative aims to encourage makers and tech entrepreneurs to resolve such issues collaboratively. Of particular relevance to our work is Smart Nation plan's strong emphasis on increasing the technical capacities of citizens, whether it be in tech-based entrepreneurial scenes or educational settings.

For instance, IDA committed an approximate S$10 million budget to build physical spaces for citizens, companies, and state representatives to engage in joint activities and "tinker with tech" [7]. While such plans express Singapore's desires to engage with smaller actors in innovation, the active role of citizens is still predetermined by the state's development pursuits. In other words, we recognize the state's strong desire but limited action to truly engage smaller technological actors both locally and regionally to co-design and co-produce "smart" technologies.

This is not to say that the Smart Nation plan is ill-intended and does not speak to citizens; where it fails at, is recognizing how citizens can also be co-creators, rather than mere consumers of ready-to-use solutions. Furthermore, Singapore's positioning of itself as a regional hub for SEA [7] suggests that technological innovation does not happen elsewhere, outside the city-state. S&G responds to these issues by steering meaningful public engagement in the making of the "smart" citizenship, as we show on the example of two organized workshops.

SQUAT & GROW

The two-week event hosted close to 60 participants who provided their knowledge and skills as well as material resources, including occasional financial donations, to create an open platform for collaborative experiments with "smart" food practices. From the total number of 21 S&G events [13], we chose two that we think fit best into the format of this paper.

Fermentation Workshop

S&G hosted several fermentation workshops, including DIY rice wine making by Sewon FoodLab Yogyakarta, kimchi tutorial by The Asian Raw Chef, and fermentation session run by a group of scholars from National University of Singapore (NUS) (figure 1).

Figure 1. Fermentation workshop tutored by NUS students. Image © S&G.

Along with these events, we aimed to support people's engagement in DIY food making and show a way to decrease our dependencies on the mass food market supply.

The NUS group gave a tutorial on vegetable pickling and introduced a scenario of a "smart" urban fermentation community connected via online tools, such as a crowdsourced online map or a Github cookbook of fermentation recipes [5]. They also prototyped a DIY fermentation incubator with light and temperature sensor regulated through the Arduino and open-source relay module. During the workshop, we further tinkered with the incubator (figures 2,3) and made some improvements (e.g. included a Wi-Fi microcontroller Photon to enable remote control).

From this initial stage, the "smart" fermentation project was released as a public initiative, which is now known as "Fermentation GutHub" [5]. The workshop organizers also asked the participants to bring their own mason jars and utensils to share them with others. This peer-sharing scenario worked well, and many participants even brought some fermentation ingredients and offered their own fermentation "starters" (i.e. microbial cultures catalyzing the fermentation process) for exchange. That inspired a scenario of a peer-managed public space, where people would freely deposit and exchange their fermentation starters. This scenario later materialized into the "Fermentation Bank" project, now operated under GutHub's agenda in the premises of Hackerspace.sg [5].

Figure 2. The DIY fermentation incubator – temperature sensor. Image © S&G

Figure 3. The DIY fermentation incubator in the making. Image © S&G.

At the end of the S&G event, we organized a tasting session of the fermented foods prepared during the workshops. One issue that emerged was participants' inquiry about the safety of consuming these DIY goods. We replied by reiterating that the peer-governed S&G initiative has no deputies responsible for safety risks, and all responsibilities are to be peer-shared. In this sense, we have seen that despite being interested in peer-learning methodologies around DIY fermentation techniques, participants were doubtful when it came to the very act of consumption of the food produced by their peers, particularly when these were not close friends. While some of the participants accepted the risk and tasted the offered food, others were cautious, claiming that this is exactly the point when DIY methods fail as compared to (allegedly) safe "evidence-based" mass-production. Concerns about the safety of DIY home-fermented foods brought some ideas related to a need to better connect amateur DIY fermentation techniques with existing sources of professional expertise. These incidents also opened a broader discussion on how to manage the potentially hazardous nature of experimental, decentralized DIY practices – an important issue to be addressed within the context of DIY hacker and maker culture in general.

Fruit BioSynth Workshop

Among the more non-conventional food experiments was the Fruit BioSynth workshop run by members of Lifepatch lab, Yogyakarta. Lifepatch is a citizen-driven collective of artists, DIYbiologists, and technologists focused on increasing access to scientific knowledge through the cross-disciplinary creation of artifacts and tools to make sense of and visualize environment in Indonesia. Lifepatch's participation in S&G emphasized the importance of bringing together different regional epistemologies and histories of scientific and technological innovation – a point we will further turn to in the discussion.

Two invited Lifepatch members held the workshop in National Design Centre with the logistical support of OneMaker Group. Building on Lifepatch's prior work, the workshop focused on the making of the "Tiger BioSynth" circuit – a bio-synthesizer designed by one of the Lifepatch members, Andreas Siagian (figures 4,5). The nearly 20 workshop participants with different domain expertise exchanged knowledge on the function of BioSynths' electronic components and experimented with its applications and uses. Thereby, the workshop aimed to demonstrate how DIY circuitry could be a sophisticated yet approachable form of technological production for data collection and translation.

The bio-based synthesizer translates conductive input data and information into sound outputs. In other words, the circuitry allows users to translate conductive inputs such as moisture (e.g. from the air, fruits, human hand, or any other biological device) into visceral sound outputs, thereby visualizing the external biodata in a multisensory way. Using simple components and equipment (alligator clips, buzzers, integrated circuits, soldering iron, circuit boards etc.) and comprehensible DIY techniques (soldering, gluing, wiring etc.), the BioSynth device serves as an important gateway for citizens to participate in the accessible technological production. More importantly, the event has also illustrated how the technical and artistic expertise from Indonesia matters to dominant tech-innovation hubs like Singapore.

Figure 4 + 5. Tiger Biosynth PCB and Layout Design by Andreas Siagian. Image ©Lifepatch

To build the Fruit Biosynths, the workshop organizers asked participants to bring fruits native to the region and treat its moisture as data that can be visualized and embodied through sound (figure 6). The amount of moisture in any one of these fruits was to be translated into different frequencies, producing different sound pitches according to how "wet" a certain fruit is. The act of translating the local fruits' biodata that one cannot commonly see and decipher encouraged participants to think about the content of various local foods beyond its "mere" nutritional values. In this sense, the Fruit Biosynths symbolized not only a need for greater access to various food data and information, but also for a reflexive multidisciplinary engagement with issues pertaining to environmental sustainability.

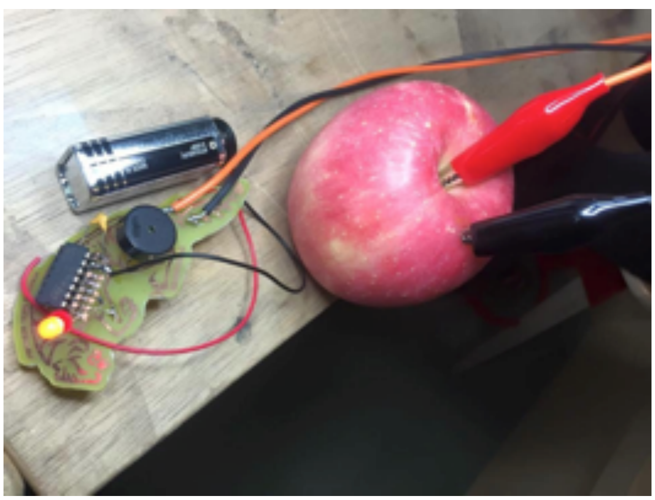

Figure 6. Fruit Biosynth device. Image ©S&G.

In all, the workshop aimed to evocate different senses and encouraged participants to adopt other modes of thinking about food and technology. From this, we learned how to run creative food experiments beyond conventional cooking practices and dependency on expensive proprietary tools. Moreover, Lifepatch's workshop exemplifies how Indonesian technologists and artists could legitimize their innovations in Singapore. S&G encouraged participants to acknowledge the technological work that Indonesians do and, in turn, question Singapore's position as an innovation hub for SEA region.

DISCUSSION

With the S&G project, we aimed to not only test possible future scenarios of sustainable and symbiotic urban communities gathered around food, but also to show alternative bottom-up enactments of Smart Nation of Singapore. By including citizens directly in the organization and decision processes around the two-week-long S&G initiative, the S&G organizers encouraged the ethos of low-cost production, free access, and community self-governance.

This DIY model was not an attempt to replace the state-initiated Smart Nation – in fact, we have seen both pros and cons of our efforts, with interesting ambiguities related to risks and responsibility-sharing. The exclusion of larger stakeholders and corporate intermediaries provided a space for flexible impromptu interactions, which brought some unexpected and desirable results (e.g. the foundation of the Fermentation Bank). However, the participants' reticence to accept responsibility for the "smart" collective actions (e.g. the tasting of the DIY fermented food) proved to be a problematic issue. In other words, while most of the S&G participants offered to share their knowledge as well as material resources to support the peer-driven food sustainability efforts, the willingness to accept the experimental outcomes of these efforts was limited. We have identified two kinds of legitimizing work that need to be done to further develop such "smart" DIY scenarios.

First, to facilitate food sustainability practices through DIY methods of low-cost peer-production, we have to better legitimize the expert-amateur ethos that citizens still perceive as risky. The traditional pre-industrial events of food production and consumption have been dissolved in the mass production processes, and the notion of everyday food making as a pleasurable and sustainable, but also experimental and just activity needs to be rejuvenated within the present context of urban food systems.

Second, we should support the sustenance of legitimate knowledge production in neighboring countries to counterbalance the position of Singapore as the exclusive innovation hub for SEA. The city-state has successfully facilitated creative production and innovation efforts across disciplines; however, the fact that intelligence and creativity resides also elsewhere in the SEA region needs to be better recognized. For instance, the Fruit BioSynth workshop, a materialization of preexistent exchanges between Singapore and Indonesia, demonstrate how diverse "smart" DIY opportunities can grow out of a mutual regional respect for each other's expertise. Instead of reiterating uneven Global North-Global South relations, the BioSynth workshop served as a platform for Singaporean participants to realize that technical and artistic expertise also exist outside of dominant hubs of tech production and innovation. By facilitating such collaborations, it is important to consider how the Smart Nation plan in Singapore can also serve as a site wherein stakeholders not only internationalize, but also regionalize technological design, production, and innovation. That is, supporting a citizen-driven Smart Nation should not preclude dismantling previous assumptions that marginal sites of innovation such as Indonesia are only capable for mass-producing "smart" technologies and are not capable of designing them.

Both efforts relate to the S&G long-term goals of inquiring into what a Smart Nation is and how it can best promote sustainable development. We see such efforts as frontiers to encourage Singaporeans to reconsider the established state-centric development strategies. Such work serves as entry-point for future S&G pursuits to support not only DIY initiatives in urban food production but also alternative Smart Nation visions.

CONCLUSION

S&G became an experiment combining food, technology and DIY methods to encourage citizens' participation in self-governed innovation outside the expert circles. This allowed participants to re-think present and future frames of local food policies and use food as a medium in response to looming Smart Nation efforts. We see such grassroots interventions in pre-defined social innovation frameworks as important and viable way to supplement state-centric visions of "smart" futures. The option for lay people to actively participate in such interventions is vital for the development of smart cities, Smart Nation, and similar "smart" sustainable initiatives. Within the SEA context, we see it as extremely important to develop transnational collaborations similar to S&G, and better connect the Singapore's innovation scene with technological and intellectual capital of citizens from neighboring countries.

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Artur Lugmayr's White Paper Collection and Online Digital Resources (www.artur-lugmayr.com)

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ABSTRACT

The white paper collection on Artur Lugmayr's website – www.artur-lugmayr.com – covers a wide range of topics. There are also additional digital resources available to the public on the website.

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Author Keywords
white paper; information resource; human-computer-interaction; usability software; Unity; computer graphics; UNIX; programming languages; ambient intelligence; sensor networks; ubiquitous computation; pervasive computation; networking

INTRODUCTION

The online white paper collection contains information for a wide variety of domains, and has been made freely available to the public. The information includes:

- A wide variety of guides for the Unity game engine software
- Tools and software resources to help productivity
- Software tools that support scientific research
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Table 1: Citation and referencing information

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@inproceedings {LugmayrWhitePapers,
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year={2016},
title={Artur Lugmayr's White Paper
Collection and Online Digital
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Semantic Ambient Media (SAME 2016):
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Other Relevant Works of Interest

If you should be interested in other works, for example. scientific contributions, please refer to the following research outcomes:

- Ubiquitous Media (or Ambient Media/Pervasive Media) [2], [3], [4], [5], [6], [7]
- Interactive Media and Emerging Media Technology [8], [9], [10], [11], [12], [13]
- Personalization, Emotional Computation, and Affective Media [14], [15]
- Business Models, Information Systems, and Innovations in the Media Industry [16], [17], [18], [19], [20], [21], [22],
- New Methods in Teaching and Learning, Design Thinking, and University Management [23], [24]
- Media Technology in Financial Services [25], [26], [27]
- Media Studies, Storytelling, and Media Theory [28]–[30], [31].

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