Constructing the Research Model of Beijing Neighborhood Through the Living Lab Method

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Abstract. Urban regeneration has become the new direction for smart city development since the rise and expansion of mass new urban information and communication technologies (ICTs), and the living lab method is now widely used in participatory design and research to deep dig the urban lifestyle in the context of regenerating urban sustainability. In this paper, we aim to build a multi-dimensional community research model to describe the Beijing Hutong life by living lab process. There are three layers in this model, i.e. infrastructure, activity and information layer. The infrastructure layer includes the physical living environment and public facilities in Hutong; the activity layer is about how citizen live in their home and communicate with their neighbors; and the information layer describes the culture, organization and policy related to Hutong life. This model is used in a collaborative project in Dashila, Beijing. The final prototypes and deliverables include the Traffic Caution Light Device, Energy Efficiency Smart-Bill and RFID tag. The model & tools developed in this project will be used to support the further urban regeneration research.

Keywords: Living lab · Design research · Urban regeneration · Smart community · Beijing Hutong

1 Introduction

In the current smart city construction, the urban regeneration and smart community has become the new trend of technology-driven solution. The living lab and participatory design method was originally developed in Europe, and there has been much experience that could be borrowed to solve the China problems. In A collaborative class hosted by Tsinghua University, Stanford University and Cinnovate Center, a NGO incubated by Intel, we try to establish a multi-dimensional community research model, in which we combine the Living lab and participatory design methods, to demonstrate the current situation of the Hutong, to discover the design needs of community users, to deal with and to carry on the urban sustainability research and the smart community construction.

New digital technology is opening a wave of urban regeneration. The Internet of things connects the city infrastructure with other public facilities and citizens [1]. Collaborative technology is facilitating the transformation of function of the community, and digital technology can help the city decision-makers in managing the integration of city resources, public service and policy more intelligently through the use of big data

P.-L.P. Rau (Ed.): CCD 2016, LNCS 9741, pp. 527–539, 2016.
DOI: 10.1007/978-3-319-40093-8_52

technology, which also enhance the public's ability to solve problems directly and tend to shape the new "sharing economy". Sharing economy [2] is changing both what we can do together across neighborhoods and how we think about sharing our time, materials and skills. It is possible to design to boost resource management, economic well-being and social resilience by fostering sharing practices. In order to take advantage of these opportunities, we are trying to pave the way to new forms of usage and introduce novel interaction between several devices.

2 Smart City Platform and the Model of Hutong

2.1 The Directions of Smart City

"Smart City" is a slippery term applied to everything from urban design to higher education policy. But the most universal definition is the use of information technology to attack urban problems [3]. There are usually two directions [4]:

First is technology-intensive city, where sensors are everywhere and public services are provided in a very efficient manner. The International Telecommunication Union (ITU) gives its own definition and interpretation "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects" [5].

Second is smart citizens, a better relationship between citizens and governments leveraged by technology. The common characteristic is embarking from the reality of the community needs, using the new techniques of digital tools, through participatory design so that the public participate in the maintenance of the new community building activities [6]. It increases both mobility and accessibility, allowing people to get access to a great amount of local information and interact with others anytime and anywhere.

2.2 Build the People Oriented Smart City

To build the smart city, we will create methodologies, frameworks, and approaches to enable the Smart Cities, a global network of smart cities and their applications that securely and collaboratively work together to improve the quality of life of their citizens, as well as greatly improve cost and energy efficiency of city operation and infrastructure [7]. To truly develop Smart Cities, a combination of multimedia, human factors, and user-centered systems methodology and design principles will have to be applied [8]. The introduction of broader participation to include such as the NGOs to improve the quality of life in old cities and to form a good environment of the platform has important significance [9].

A lot of smart city projects have been created taking advantages of the development of mobile devices [11]. Urban Mechanics New office and Boston University's research and development of the application of Street Bump—Boston is a typical case. When the driver encounters turbulence, the software will use the phone's accelerometer to detect the data which is later returned to the municipal government [10]. Nairobi [12] is one

of the fastest growing metropolitan cities in Africa. Based on the survey's findings, the design team develops a mobile crowdsourcing application, called CommuniSense, to collect road quality data. The application serves as a tool for users to locate, describe, and photograph road hazards. Through "I love Beijing" [10] appliance reported to the municipal government in China, the application can also find a map of the city market. Through crowdsourcing data people can use low cost sensor to measure and create environment of crowdsourcing map; city government can use crowdsourcing data from social media sites and smart phone sensors as a supplement to the urban network.

The Baitasi is an old neighborhood near the White Dagoba Temple with low-rise residential housings and building districts that need regeneration. The Baitasi regeneration plan is part of the 2015 Beijing international design week. The project explores another urban renewal and community reconstruction through the design. Setting the context in The White Pagoda Temple region, the project is themed around "connection and symbiosis" and explores how to use culture as clues to the past relationship groups within the community integration and today's Internet and smart hardware, The Baitasi regeneration plan include physical space update, basic energy transformation, public environmental reconstruction and the overall region revitalization, while maintain the unique culture of the neighborhood.

2.3 The Model of Hutong

But the building of new form of the Hutong community also encountered some problems. First of all, although a lot of Hutongs are located in the historical and cultural protection zone, they are not in good conditions. Secondly, Hutong tourism planning and tourist routes for especially foreign visitors are not well-developed, which need to be improved. Thirdly, while Hutong path can play a significant role in urban traffic system, it is a difficult task to find a balance between modern transportation planning and the original atmosphere maintaining. Fourthly, life quality of Hutong residents has not been improved; some residents are reluctant to change the traditional way of using coal for heating [13]. Although there are continuous explorations in this area, the policy measures, regulations and other implementation of the test is lacking. Therefore, we attempt to use the method of living lab to build a multidimensional research model, to encourage residents' participation in the design and plan of their neighborhood, to meet the needs of both Hutong revitalization and the residents' life quality improvement.

3 Living Lab Method and Multidimensional Research Model

3.1 Living Lab Method

Living lab research method was originally proposed by an MIT professor William Mitchell. It considers "living lab is a research method, in the diversity and evolution of the actual living environment through perception, prototype, verify and improve all kinds of complex solution", laboratory environment brings the user to real life to verify whether the demo is valid or not.

Living lab is a kind of innovative research tool, used to improve the program to develop the innovative products and services, through the actual application of the test to enhance the applicability of products in the future market. Employment of user-driven, open innovation pattern enables users to also become innovators. In the open living laboratory, we aim to make the cycle of new product life endless and achieve continuous improvement of the new products and services research development.

Living lab researchers advocate methods that facilitate co-operation in teams with mixed expertise. These participatory methods provide a "third space" [14] for designers and users to meet in. Artifacts or representations [15] that make sense to everybody facilitate cooperative work; they further promote mutual understanding and help making implicit knowledge explicit in the process [16] (Figs. 1 and 2).

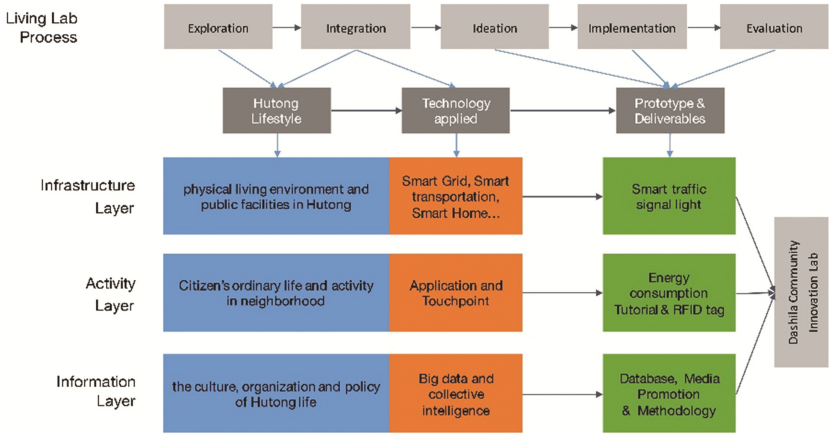

Fig. 1. Living lab research process

Fig. 2. Multi-dimensional community research model

3.2 Multidimensional Research Model for Hutong

Beijing Hutong is a place with rich history and culture. What we wish to do is to conduct an in-depth research based on Multidimensional research model to construct new forms of community. To focus on our research, the program is narrowed down to the TieShu byway whose environment layer, activity layer and information layer is our main attention. Through the development process of the city development model, we design the model of Hutong focused on research direction from "bottom to top ". At the same time, multi-dimensional research model is a problem-oriented model owing to the growing complexity and uncertainty of the city. To launch our design, we invite experts, research teams, user groups, and the investors to participate in the whole design process.

Environmental Layer. Hutong of the environmental layer, including the physical living environment and public facilities. In this layer we will use more research methods to study the morphology, ecological system and social environment of space. Due to the drawbacks of infrastructure, some problems such as Hutong road traffic jam is likely to occur. However, there are positive cases, such as Hutong nameplate indicating system, which is not only a part of a sense of the Hutong resident self-identity, but also helps Hutong visitors with valid travel route indication information. Hutong has its own unique environment, Beijing quadrangle is semi-closed house, the gate of the quadrangle has a high threshold, so the car can't be parked in the courtyard. In the past, the narrow roads were not an issue as most people used to travel around by walking or cycling. However, as more people switch to cars and electric bikes, it poses more transportation problems. Some of the roads are simply too narrow for cars to pass through causing jams. Whether the original shape of the Hutong is to be fully retained and how to solve the history building problem, we need to consider profoundly.

Activity Layer. In order to understand the current situation of the life of the people in the Hutong, we need to visit the family environment of the residents in the Hutong. We divided user activity layer into two parts including "citizen's ordinary life and communicate with neighborhood" and "application and touchpoint". As a traditional way of life in the community, the people living pace is slower, their entertainment and leisure style is more traditional, and the interaction between the neighborhoods is more close. For example, the residents of the Hutong at home like watching TV, some residents still maintain the habit of listening to the radio. Quiet and leisurely lifestyle in Hutong reflects the citizen are mostly senior citizens and they are not used to accepting new things. What we need to do is to understand the core Hutong community culture, respect the local resident lifestyle. So our design should also be maintained as part of the Hutong emotion.

Information Layer. The use of cultural communication, government policy and technical means facilitates the association of the physical world and the virtual world. Construction of the city's information technology development is inseparable from the wisdom of the community. The construction of intelligent community utilizes the new generation of information technology such as the Internet of things, cloud computing, mobile Internet, intelligent terminal information and automatically perceive, timely transfer and timely publish all kinds information closely related to people's life to

achieve community "management, education services," organic integration, to improve community functions and to strengthen community service [17]. In information management, the government through the promulgation of policies, regulations influence on the impact of the community. For example, by the end of August 2014, all Hutong residents had started to use electric heating. So the government gave Hutong citizen special subsidies for "coal to electricity" project. Support from the government gradually helps the Hutong residents adapt to the new energy policy.

4 Living Lab Research Process

In order to carry out the problems and solutions for Hutong, we obtained skills from our Living lab participatory process. We use different design methods do Living lab research and the following mainly takes Hutong traffic problems as an example (Fig. 3).

Focus point		The user pain points	Design methods	Layers	Solution
Outside	Traffic jam in Hutong	Traffic jams often occurs	Observing	Information Layer Environment Layer	Traffic Caution Light Device
		Narrow road in the Hutong	Measuring		
		A lot of cars in Hutong	Counting		
		Road bearing capacity is small	Interview		
		Impact on pedestrian safety	Workshop		
Indoor	Hutong energy	Energy bill's information is limited	Observing	Information Layer Activity Layer	Energy efficiency Smart-Bill & Stickers
		Some of residents don't pay attention to the ennergy bill	Interview		
		Energy bills difficult to keep tidy	Observing		
		Energy saving consciousness	Workshop		

Fig. 3. Living lab research process summary

Observations. Observation [18] will also help us to understand users' context, establish common ground, and identify important terminology for better communication. From our observation, even though there are only 2 lanes in the area, the roads do not jam up often. This could be due to the fact that there are a larger percentage of people choosing to walk instead of drive.

We can observe from this map that the width of the Hutong is inconsistent. The inconsistency especially troubles new drivers as they are unfamiliar with the roads. If they were to drive into a narrow road, they might not be able to proceed. Also we noticed that there were several cars parking along the roadside permanently. Considering how narrow the roads in the Hutongs are, car parked along the Hutong will only make it narrower and inconvenient for drivers and other road users.

Interview. The Tsinghua group made several trips to Dashilar Hutong to conduct the interviews. For interviews that were conducted in the residences, they were arranged by student representatives and the community partners. With the help of our community partners, we were able to arrange interviews with residents of the Hutong and even conducted interviews in their houses. These interviews generally lasted an hour as we went in depth asking about their lifestyle in the Hutong. Other than that, we also approached store owners by buying a drink from them and pedestrians in the Hutong with a short interview. In total, we conducted interviews with about 40–50 people.

Measuring and Counting. During one of the site visit to Dashilar, the Tsinghua group decided to measure the width of the alley without the use of professional tools. Instead, we measured them using our arm span. Every member linked arms and we calculated the width of the alley according to the number arm span needed to reach from one end to another end. With that, we made a map indicating the width of the Hutong.

Workshop. We test whether our ideas are feasible with a large population of Hutong citizens from two groups: The first group are 20 young people, the other group are 20 middle-aged citizens. By introducing participatory workshop, these ambiguities are welcome: they invite participants to ponder advantages and drawbacks of each interpretation and form an opinion about what they saw. This is a way to engage them to become designers. For example, the young group of participants hold that solving the problem of traffic jam requires that there are more parking lot and increase parking capacity. The middle-aged group of participants believe that the problem is because many residents are more willing to park the car near their house. One possible solution to this would be to fine people who parked on the street at a rate that is higher than the rate of parking lots close. Thus to disincentive people from parking there.

Data Monitor. We use map navigation app with GPS navigation function. The observation was focused on the Beijing Dashilan road, based on the monitoring data of map navigation tools, we can use Hutong road congestion data for quantitative analysis and know when the rush hour of the day. But the disadvantage of this method is, nearly most of map navigation app only collect the road congestion data of width more than 7 m in Hutong. So a number of narrow lane road congestion data remain sparse.

5 Findings in Different Layers

5.1 Reasons for Prototype Generation

Transportation Problems that Arises Daily in Tieshu Byway. According to Living Lab design, we find the main cause of traffic jam turns out to be an illegal parking on the limited byway. Most of alleyways near Tieshu byway are measured from 5 m to 7 m^2. The heavy traffic jam happens if the cars come from both directions into one alley, blocked by parked cars. In this situation, car drivers are stuck on the street as long as they enter the jammed area since other drivers come into the area back to back. We need technological prototypes to help us explore how to deal with traffic jam. Therefore, we

felt it necessary to come up with a solution to ease the traffic situation. This is also the problem belonging to the environment lever in Hutong.

Lack of Information on the Energy Bill. The investigation of real energy bills of the respondents validates that the current energy bills could be improved to be more user friendly. Considering that the energy users in the Hutong are the low income old Beijing citizens, the visualizing information would be readable for them. Also, since the existent bills did not contain safety tips and ways to save energy, the inclusion of those advice on the new smart bills will be the most effect way to encourage household to economize on energy.

6 Prototype and Demo Presentation

6.1 Demo: Energy Efficiency Smart-Bill and Stickers

Based on the original electricity bills which is difficult to understand, we made a visualization improvement for the Hutong residents. Firstly, there is a clip at the top right corner. It is cut into a "U" shape which can help users to carry bills. Secondly, with the content of the bill, residents can compare the recently electricity cost and the cost in former years through the bill, so that they can have the idea of when they use most visually. At the same time, the residents' electric bills would be compared with their neighbors. Residents would know if their energy use is higher than the average level or not, which could help them save energy. Thirdly, It is designed to be a label that can be pasted in the form of two-dimensional code or used FRID technology, users can scan through the phone to get more abundant information. In addition, the households can attach the stickers on their appliances, such as fridge, air conditioner, heater, and TV. Residents could paste them on the appliances so that people would know which kind of appliance costs more electricity, and which kind of appliances may be ignored. Moreover, considering stakeholders including power suppliers and advertisers, there is an advertising area on the bill to improve the feasibility of the bill design. We also encourage residents to pay the electricity bills online, by which residents could receive online electricity bills containing even more information than those papery. The form of label allows the user to see the information more clearly and obviously.

6.2 Traffic Congestion Traffic-Caution Light Device

From the interview result and our field observation, traffic congestion problem was very serious in Hutong. Congestion usually happened in the main street, when people went to work and went home. By measuring the width of streets and analyzing the shapes of Hutong, we found that traffic congestion was mainly caused by a strong need of parking area, the narrow streets, and the large vehicle flow (Fig. 4).

So we design the traffic caution light device focused on the Hutong road's width less than 7 m. When traffic congestion happens and lasts more than 5 min, the traffic caution light will turn yellow. It means there was a traffic jam but just lasted for a little while. But when the light turns red it means that the traffic jam was last more than 10 min so

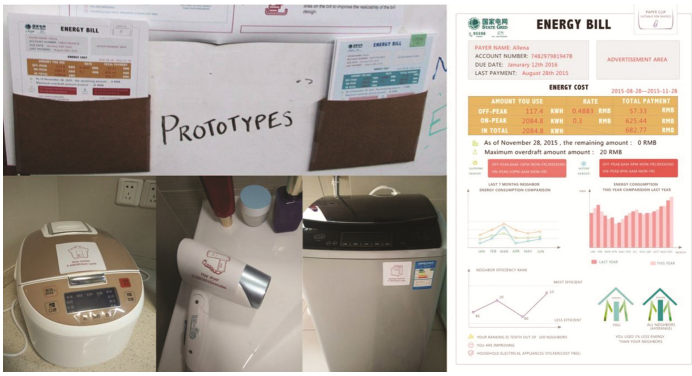

Fig. 4. Energy efficiency smart-bill and stickers demo

we do not recommend you to drive through this road. In this way, we could remind the drivers, if there's traffic congestion, drivers are advised to take a turn or stop their cars in advance. The traffic light demo was made by Arduino Electronic component and it includes a number of Infrared sensors. While it will also bring some problems. For example, we need so many Infrared sensors set every few meters on the road. Obviously, it will cost a lot of money. At the same time, the Infrared sensor to identify the accuracy of road congestion is not very high, because the temporary stop of the vehicle blocking the side of thee roads will cause the signal's error. So it is still a simple demo, we hope it can be further improved, using NFC technology to identify the running condition of the car on the road and judging the road congestion more accurately (Fig. 5).

Fig. 5. Traffic light device demo

6.3 Evaluation

There are various modes of approaches to measure demo effects. Traditionally, there are two methods including using questionnaires administered after an experience, which asks the user to rate his/her feelings about what happened, and analysis of videotaped sessions with users that typically combine interpretation of think-aloud commentary with deciphering of other cues of emotion (smiling, gestures and the like) to develop an impression of user's effective reactions [19]. In the design process, we ensure that the

participatory evaluation of the whole process is sufficient to open, and maintain interactive response and feedback to the public evaluation (Fig. 6).

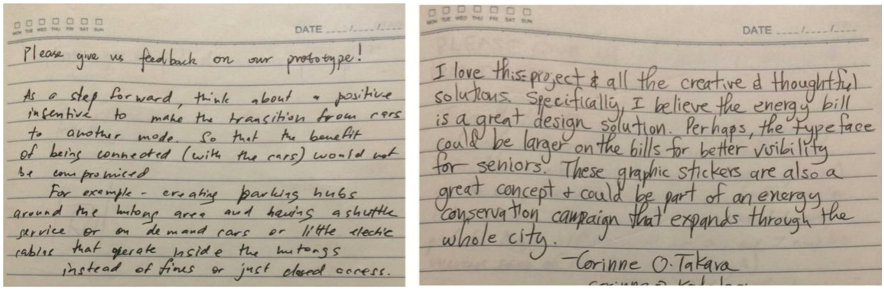

Fig. 6. Audiences' comments in the project exhibition

6.3.1 Energy Efficiency Smart-Bill and Stickers Evaluation

So we participate in design method to evaluate our design demo, we give energy efficiency Smart-Bill & stickers to 50 citizens who live in Hutong, recording user's behaviors when they receive bill's (including facial expressions and body languages). Ask users about differences between the old bill and the efficiency Smart-Bill Energy and let us be informed of whether differences are important to or offensive to users. We focus on the behaviors when they receive stickers, for instance, whether user will paste stickers immediately on household appliances, or drop it directly. We ask the users whether they like this design, whether they think it is useful and able to enhance their awareness of environmental protection, and other related issues.

According to the feedback: A number of payers do not concern with their energy bills; Some payers who do business in the Hutong regard the utilities as the fixed cost, which is inflexible to be saved. While some residents consent that current bill provides little information, so we still have areas to improve.

6.3.2 Traffic Congestion Traffic-Caution Light Device Evaluation

In user testing, because we only use Arduino to complete a demo, not in the real road in the Hutong erecting sensor monitoring road congestion. So we built a simulated Hutong crossroad experiment scene, inviting Hutong citizens (each citizens can control in the hands of the toy car, the simulation Hutong's "driver"). We set up demo at one of the intersection. We put the device to test whether the drivers were able to make the corresponding reflection including making timely feedback and congestion avoidance behavior when they saw the light. By testing 30 drivers, we watch user behaviors to prove that the analysis of the design of our program is able to play the role of traffic congestion warning indication. According to the results of the experiments, we found that 30 drivers would pass through the road directly when they saw the green light. When the light turned yellow, 15 drivers would stop and observed the road condition. While only when the light turned red, there would be more than half of the drivers to stop and look, paying attention to light meaning, and made corresponding reaction such as

stopping or turning to another intersection. The experiment reflected that our designed devise confused the drivers, so the recognition was not strong.

Through prototype testing, we provide a reliable direction for future improvements based on the feedback from the user. The challenges about Caution Light Device Traffic: Some of the drivers may not be bothered with the device; The drivers cannot detour or u-turn once they are in the lanes in the Hutong. What the design can borrow ideas from are as follows: One of the reasons for traffic jam in Hutong is that the drivers do not know this road has been blocked and continue to go inside; There are a large number of the users hoping there is a traffic jam early warning function combined with existing mobile map navigation, so it can design a suitable route to avoid congestion ahead of time.

7 Discussion and Next Steps

A suitable model helps us to better perceive the problems we study, to find relevant answers. Model is the basis of our understanding. Through the model we can describe the multidimensional level of the Hutong, to help us to understand the culture of the Hutong and the real needs of the residents. We develop design tools to help users to better participate in our project, better explore and define the user requirements, more effectively get useful information and data. The project has completed the first iteration process from research to evaluation, in which we validated the first major assumption about the needs of local citizen. Next challenge is how to expand this project to the broader community [20]. Move toward the goal of converting our project into a sustainable activity to revitalize the local community.

New technologies will be the good way to collect the data, and record people's activities in the Hutong, but we need to think more about how to embed it in people's daily life in an unobtrusive manner. We will look for the opportunities to establish a sustainable mechanism and ecosystem. In the case of Hutong, we will co-build the community innovation lab with Cinnovate Center to promote community residents' participation in their own initiative, and to form the effective mechanism among the community residents, the changemakers, NGOs the neighborhood committee and local government.

8 Conclusion

Living lab as an innovation method has been widely applied in the Europe, but in China it is just at the very beginning stage. In this paper, we use it to construct new forms of the Beijing Hutong. We designed Energy Efficiency Smart-Bill and RFID tag, which is used as the guide and instruction manual to carry out the experiment. For congestion in Hutong, we do technical prototype to demonstrate a Traffic Caution Light Device, which can indicate road congestion in the Hutong and also act as one of the Hutong's geotag. These tentative prototypes supported the further researches in the infrastructure level, activity level and information levels of Hutong. The model combined with the Living lab methods assist us to demonstrate the state of the Hutong, to discover the design needs

of community residents, to carry on the sustainable urban development and to construct the smart community in the future.

Acknowledgments. Many thanks to Deland Chan and Kevin Hsu at Stanford University and Lan Li at Tsinghua University co-conduct the class, and the project related students including Yinshuai Zhang, Ellena Jang, Taoran Tang, Adelbert Tan, Cindy Lin, Karen Lee, Julianne Dones, Alicia Menendez, Daphne Gan, Dongda Wang, Zhijia Chen, Yingqi Wang. We express the sincere thanks to their contributions.

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