GEAR APP: AUTOMATED BICYCLE ROOFTOP STORAGE SYSTEM FOR SMART HOMES

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ABSTRACT

As the amount of bicycles in large cities rises and outdoor space is becoming increasingly insufficient, a need for alternative storage spaces has emerged. Bike theft is also a major issue and is more frequent because of the huge number of bicycles. A secure automated rooftop bicycle storage system is proposed in the theme of "Smart homes", enabling people to easily store and retrieve their bikes through this system with the use of a mobile application and RFID identification to establish safety and convenience.

INTRODUCTION

In an ever-changing world, the need for future vision is more important for businesses than building long lasting products. PEAB is a construction firm and their "products" live for more than a 100 years. By identifying which problem areas are predicted to expand in the future, PEAB can create more reliable concepts. One of the greatest issues in future city housing is space optimization. As ground space becomes more valuable, houses get taller and the interior areas get smaller. Cars are pushed out of the city and public transport, walking and biking increases. The amount of bicycles is expected to be tripled by 2025 (Trafikkontoret 2014).

As the number of bike commuters is increasing, the need for bigger and better storage of bikes becomes a demand. Furthermore, the limited space requires the generation of creative solutions for bike parking, utilizing currently unused spaces. The city of Gothenburg just recently closed the deadline for a competition on the topic.

Providing sufficient space for bikes is only one aspect of parking bikes. Security is one more major issue since as many as 60000 bikes are stolen each year (Brå 2014). Increasing convenience by ameliorating these problems is also needed to promote the use of bikes over other means of transportation especially in the context of a stressed morning situation. These problems cannot be ignored by the construction firms since the P Norm of Gothenburg says that "Parking for bikes by homes and offices shall be offered on the ground owned by the building." and that "The parking areas shall be safe, of good quality, have weather protection and there should be opportunities to lock the bike indoors or in a fixed place." (Parkeringspolicy för Göteborgs Stad 2009)

Most parking for bikes that is offered close to houses in Gothenburg are bike rooms that are often crammed with bikes and it is a hassle for people to retrieve their bikes from there. They are secure, but only until someone breaks open the door and picks the bikes that are of any value. The bike rooms also claim a lot of space that could be used for alternative neighborly activities.

CONCEPT

The aim of the project was based on the problems stated above and formulated as:
To create a secure system for bikes that is easy to use and that does not take space that can be claimed for alternative uses.

Looking at spaces that today are not used for anything else, below ground, façade and rooftop where identified. The earliest concept only made use of the façade but

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that made the bike weather exposed and also demanded a very complex system for storing and retrieving the bicycles.

Placing the bike parking underground was also investigated but was abandoned due to high costs and inconvenience if there was a power failure.

Sending the bike via the façade up to the rooftop therefore became the concept to be further investigated. Locking the bike onto the system using an RFID key and sending it to a specified terminal slot in a rotating cylindrical structure, resembling a carousel, on the rooftop.

Since it will take some time for the bike to travel down the façade, the owner is equipped with a smartphone application to call for the bike when getting ready to leave the apartment or getting closer to the home. The bike will then wait for the owner, locked by the RFID system. However if the owner does not show up for a specified time, a use-case based on user evaluation in future work, the bike will have to move back up. This will also be the case if another user calls for their bike – a queue will be created and if the first bike is not picked up, it will then be moved back up and the second in line will get a way to move down. If there were more than one access point, those would be used instead.

Information about time and location to pick up bike would be accessed via the smart phone application. It will also have a countdown timer for when it will be moved back up or when another user is queuing up.

The target time for the bike to get to the access point in the example house is considered to be less than five minutes. This time is based on what the bike commuters in the group found to be a reasonable time and need to be further evaluated and tested both on what is possible and what is stated as a demand from the users.

METHODS AND PROCESS

THEORETICAL BACKGROUND

In the early stages of the project the three main problems were elicited: space, security and convenience. By keeping these three in mind in all concept development the evaluation of concepts were more easily performed: "will the idea provide support in finding solutions for the stated problems?" Inspiration for this was collected from the effect mapping way of working (Ottersten and Balic 2007).

Given also the theme of "smart homes", a vision-driven approach (Ishii et al. 2012) was followed. Ishii et al. (2012) underline that vision-driven design is critical in 'fostering quantum leaps by looking beyond current day limitations'. Thus, the solution proposed by this paper is aiming to illustrate a vision of a bicycle storage system that could be potentially feasible in the future given the rapid technological advances and promoted by the emerging problems that are highlighted. Nevertheless, technological and monetary aspects were seriously considered. Initial ideas that introduced excessive costs or technologically unrealistic solutions were immediately abandoned.

The divergence methods (Jones 1992) include mainly benchmarking through online research and observation aiming to study existing creative solutions in the city of Gothenburg. The online research allowed the group to explore concepts and designs from many different parts of the world. By conducting early brainstorming and prototyping as a form of grounded theory (Hook 2014) too much knowledge around what is and is not possible was not acting as idea stoppers. Iterations with stakeholders with lo-fi prototypes allowed the concept to be developed further.

RESEARCH

The concept of a mechanical rooftop bike storage is already considered by engineers for the Amsterdam bicycle problem (Geere 2012), though not explained and implemented more than the concept level. The automated underground system of Japan (Laughing Squid 2013) is really impressive and is one working solution that uses space efficiently and securely below ground to store huge numbers of bicycles. It created serious considerations for using the basements of the building for bike storage, but was abandoned due to flood regulations (Göteborg stad 2012). A carousel type cylindrical bicycle parking system (Carousel 2014) seconds the idea of using a similar mechanically rotating structure for storing bikes on the roof. Inspiration was also gained by the "smart office" by Maverick (Maverick by Sigma 2014), where employees are able to book group rooms preemptively through their phones and check-in by swiping their phones by using the iBeacon system. This gave birth to the idea of using a mobile application for bike-retrieval and secure authentication using RFID tagging.

Testing of existing parking solutions was also performed in order to get a better understanding of how to connect the bike, how to place it, move it up the façade etc. The Gothenburg Central Station's bicycle parking system was visited and promoted the idea of securing the bicycle on a metallic base, as it ensures stability, and smooth transportation over the façade railway system.

USER STUDY - STAKEHOLDERS

In the early stages the concept was presented to three bike commuters for the approval of the concept. The frustration of retrieving their bikes from the back of the bike room or to have their bikes stolen proved to be something that they had experienced several times before. For these reasons, the concepts introduced were conceived to be a great solution.

Interviews with both the chiefs of city development, Park & Nature and the bicycle planner of Gothenburg municipality were conducted. These were done to evaluate the design ideas and get their perspective on bicycle storage. In both interviews, great feedback was received and a general interest in the concept and design was expressed. Bicycling is growing every year and the problem regarding where to store them all is something that is heavily discussed by the municipality. The interviewees also brought up the problem with different shaped bicycles, such as cargo bicycles that are on the increase.

PROTOTYPING

The earliest prototypes consisted of conceptual sketches, but the difficulty in conveying the vision onto paper was a setback, so 3D versions of the prototype were created for illustrating better what the final prototype would look like.

By starting the prototyping of the façade system early in the design process, some big challenges were identified and solved before the final prototype (Kuniavsky 2010). Several simple pulley systems out of Lego and cardboard were made to get an understanding of how the system could work. These early prototypes were only powered by hand, but these learning were made in order to implement the system in the final prototype.

RESULT

The final prototype is a 1:16 model of a house. The house has the dimensions 1x1x0.8 meters. It is built with a wooden frame and plywood façade and roof. The bicycle retrieval system is built with Lego parts and is powered by a Lego Mindstorms NXT controller (Lego 2014). The system can be used to bring the bicycle carriage up and down the façade (figures 1, 2).

Figure 1. Model Bicycle transported over the façade.

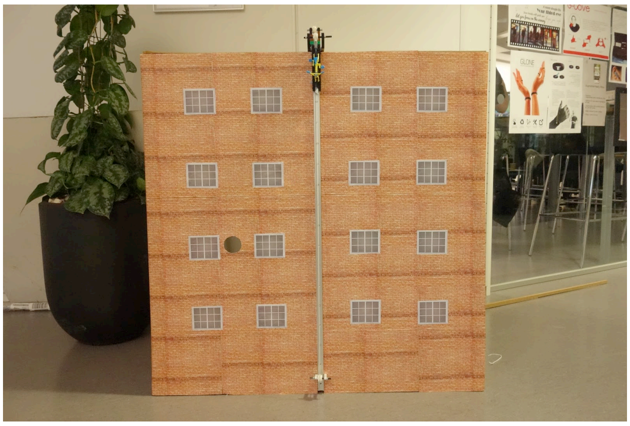

Figure 2. Final Model Prototype.

Looking at a house with four floors, each floor with an apartment 54 m^2 gives an estimated rooftop of approximately 256 m^2, giving sides of 16x16 meters. Creating a rotating cylinder with a diameter of 16 meters. Each bike would only need 2 meters of the outer rim, and about one meter of the circumference. This would create parking for approximately 50 bikes giving space for 3.3 bikes per household.

In the final prototype the cylinder storage is made out of cardboard and transparent plastic sheets and is controlled by an Arduino (Arduino 2014) connected with a simple electronic circuit. It is used to spin the cylinder into position for loading the approaching bicycle.

The smartphone application (figure 3) is only on a start page of the design stage, allowing the user to get the bike, track the estimated time of arrival at the checkout and when it will be returned to the cylinder if not checked out.

DISCUSSION

It is indisputable that there is a serious need for creative bike parking in future cities where cars have been moved out, but is this concept really the best way to store them? If the house was built around the aim of creating a secure, space saving and convenient bike storage system would this have been the ultimate solution? Climbing the façade is time consuming and the whole automated system is undoubtedly complex. In addition to this, automated systems are always exposed to the threat of a power fail or any other kind of mechanical problem.

Having things moving up on a rail using a wire or a chain will also create considerable noise, especially if the house is made of concrete. This means that the system needs to be also soundproof which will raise the costs further. Thus, emerging problems should be identified and the costs for avoiding them should be calculated.

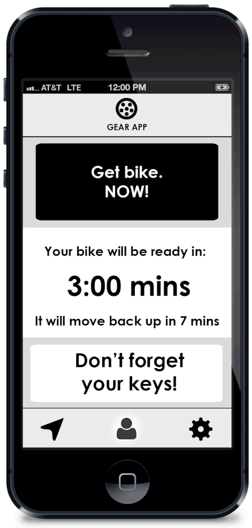

Figure 3. Prototype of the mobile application.

CONCLUSIONS

An automated rooftop bicycle storage system is one of several alternative solutions to the problems analyzed in the paper. Though, no ideal solution could be defined without being implemented in new residences and it is very difficult to enhance existing building with this system. The automated mechanical solution for transporting the bikes, coupled with the RFID identification and the mobile application promotes the theme of "Smart homes", as autonomous convenient solutions tend to be the path to the future. However, the cost is rising and the feasibility of the implementation in relation to a considerable customer value is controversial. Hence, the emerging idea, that will allow the users to retrieve and store their bikes manually in the roof by using the regular elevator, was considered seriously as an option.

The user study and research is a result of the constant rising need of new secure spaces for bicycle storage. The concept of using unoccupied spaces, like the roof and the facade, is a clear path towards a less bike-cluttering environment and safer bike storage. The combined insights and contributions of interaction designers, engineers and architects are essential for formulating an inarguably feasible solution.

FUTURE WORK

The project has only developed a concept prototype, and there is still a lot that need to be designed and developed. For example how the bike is moved from the rail of the façade into the cylinder.

There are a few outstanding issues regarding the user interaction that need to be further investigated. These include questions such as: What is a reasonable time for the bike to move down? If the bike is not checked out how fast should the bike move back up into the cylinder? And should there be a punishment system each time that happens?

Noticing how public bike parking is becoming of more importance, this system could also be adapted to be a public parking. How would the security then be handled if not by RFID?

This system could also be enhanced with services such as gamification features in the smartphone application or storage of rain clothes or helmets for example.

REFERENCING

Parkeringspolicy för Göteborgs Stad (2009) http://www2.trafikkontoret.goteborg.se/resourcelibrary/Parkeringspolicy20091008.pdf

Arduino (2014) *What is Arduino*. http://arduino.cc/ (Retrieved: October 28, 2014)

BRÅ. (2014) *Cykelstöld* https://www.bra.se/bra/brott-och-statistik/cykelstold.html (Retrieved: October 28, 2014)

CAROUSEL CYKELPARKERINGSHUS. (2014) *Cykelrummet på gården.* http://www.plug.se/ (Retrieved: October 28, 2014)

Geere, D. (2012) *Amsterdam looks at rooftops for automatic bicycle parking (Wired UK)*. http://www.wired.co.uk/news/archive/2012-06/01/velominck-bikes-on-rooftops (Retrieved: October 28, 2014)

Göteborgs Universitet Handelshögskolan. (2012) *Bebyggelseutveckling i det vattennära stadsrummet Göteborg*.

Ishii, H., Lakatos, D., Bonanni, L., & Labrune, J. B. (2012). *Radical atoms: beyond tangible bits, toward transformable materials*. Interactions, 19(1), 38-51.

Kuniavsky, M. (2010) *Smart Things: Ubiquitous Computing User Experience Design* ISBN-10: 0123748992

Laughing Squid (2013) *Eco Cycle, Robotic Underground Bicycle Storage Systems in Japan*. http://laughingsquid.com/eco-cycle-robotic-underground-bicycle-storage-systems-in-japan/ (Retrieved: October 28, 2014)

Lego (2014) Mindstorms. http://mindstorms.lego.com/ (Retrieved: October 28, 2014)

Maverick by Sigma. (2014) *SmartOffice.* http://maverickbysigma.se/en/ (Retrieved: October 28, 2014)

Trafikkontoret. (2014) *Göteborg 2035 Trafikstrategi för en nära storstad.*