reCHARGE w/ ROBO

Electric Vehicle Infrastructure design studio

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Abstract. *Current emerging urban infrastructure increasingly depends on control systems and the understanding and application of these systems in design can create re-imagined urban spaces. The use of this technical field of mechatronics in architecture requires interdisciplinary collaboration and a working understanding of control systems, sensors and actuators. Through a research and related graduate design studio, this paper discusses the potential for reimagining urban infrastructure in relation to the electric vehicle recharging process. The new infrastructure of the electric vehicle recharging station provides an interruptive urban site for applying the technology as well as for developing synergistic adjacent programs.*
Keywords. *Design; Architectronics; Robo Design Studio; Electric Vehicle; Infrastructure.*

INTRODUCTION

The experimental ASK ROBO studio operated at the intersection of mechatronics and architecture (*ASK or Architecture for Society of Knowledge, the new EU sponsored Master Program offered at Faculty of Architecture of Warsaw University of Technology. The problem based learning of the ASK design studios consists of: CAD, problem modeling + simulation | VDS, distributed design collaboration | CNC, numerically controlled prototyping and design fabrication | PARAmetric and algorithmic architectural design | ROBO, responsive public space and architecture supported by mechatronics and robotics | Society of Knowledge program is redefining space design contexts and addressing issues related to crisis of globalization. See [1] for more*). The kinetic, performative aspects of design together with basics of robotics were briefly addressed during the related seminar course, together with the review of the few precedents and writings. The main design problem was set to explore the conceptual construction of a responsive urban fragment in order to improve quality of life and to popularize the infrastructure for the emerging electric car culture. Among the benefits of the electric vehicle (EV) is its dependence on energy stored in its batteries and the resulting pollution reduction in comparison with internal combustion driven vehicles. One of the obvious limitations in EV acceptance is absence of the adequate support infrastructure in the face of the current limited range of EV (about 160 km). From the aqueducts of ancient Rome to Hector Guimard's Paris Metro, new infrastructures have continuously transmuted life in the City. Through the examination of contemporary EV recharging process one could reconcepualize it as a new type of urban node, located with the diverse existing activities. [Meyboom]: "*...there are a wide variety of considerations, from the basics of range coverage and relieving range anxiety, to locating stations where they will most easily attract*

drivers, considering what drivers might do while charging, and evaluating feasible economic models, as well as integrating successful branding strategies. All these factors play into the success of the charging network, and therefore the overall adoption of EVs."

The location of EV recharging facilities varied from the performative resolution of contested public infrastructure space, to the unexpected transformation of the predictable cityscape. Fast charging of the electric car at this point in time can easily take 30 minutes and unless a driver can use his or her time effectively while charging the vehicle "...time is wasted and the technology will not be looked upon favorably. Providing complementary activities is a precondition to successfully locating EV charging stations." (Meyboom 2011).

While charging is the primary purpose of the EV station, other tasks may be accomplished in conjunction with it. In many cases the surrounding commercial areas can provide supplementary activities, as it is case in EV re-charging bays located in Warsaw's Galleria Mokotow parking. Presently in Warsaw there are over 10 recharging station available to the public. While these facilities are currently made available at no cost to the user by the sponsoring power corporation, RWE – Poland, their impact remains rather limited. To promote, expose and make visible the process of recharging, ASK ROBO Studio undertook the EV recharging project. The objective of integrating additional functions together deployment of mechatronics in architecture was incorporated into the program. The recharging unit was to benefit from some other function integrated with it. For the purpose of the project designers considered integrating diverse activities with the charging unit - activities such as a post office, energy harvesting canopy, bus stop, tree planter, gallery, bench, homeless shelter, street art, kiosk, playground, grocery shop, parking meter, dry cleaner, drug store, flower shop, fast food vendor or park & ride were all seen as eligible.

The reCHARGING station's initial placement was intended to be at a significant location within the city, as the high visibility of the first few stations will contribute to development of a successful, mature network. Many questions remain such as: what happens if a person leaves their car in the charger for much longer than it actually requires? Designs addressed this problem by limiting parking time, having a design element to signify it through change its form or color, etc. The pilot stations emphasized the following objectives:

1. Visibility - raising the profile of the electric car;
2. Convenience - demonstrating that electric cars are simple to run and recharge;
3. Cultural Branding - to showcase the lifestyle brand of the electric car, increasing mass appeal and accelerating its popularity.

PROJECTS

The 'convertor projects' are understood here as an object or space that alters their initial state or context. The ROBO projects aimed to broaden the scope of what architectural design entails through a speculative exploration of new, responsive technologies relevant to the phenomenon of urban electric car emergence. Similar to a vehicle, an architecture in motion become a machine – permitting us to reimagine architecture, not as something that is static, but as something that adjusts according to our interaction with it, performing to increase our quality of life. The environment becomes responsive and more akin to nature in its responsiveness. What results is a design approach which returns to an unnatural nature.

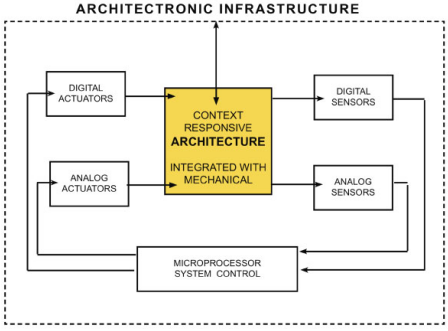


Figure 1
Diagram of relationship between architecture and control system elements (first published at ETH, 2011).

The main problem set within the studio required designers to situate the EV reCHARGING station (+) schematically and augment it with the additional function(s). The focus of the studio was the detailed design of its kinetic fragment related to concepts like expanding space, harvesting energy, performing building elements, interacting streetscape, announcing presence, securing the unit and/or providing accessibility, etc. The station multipurpose or multitasking element (+) was to adjust itself dynami-

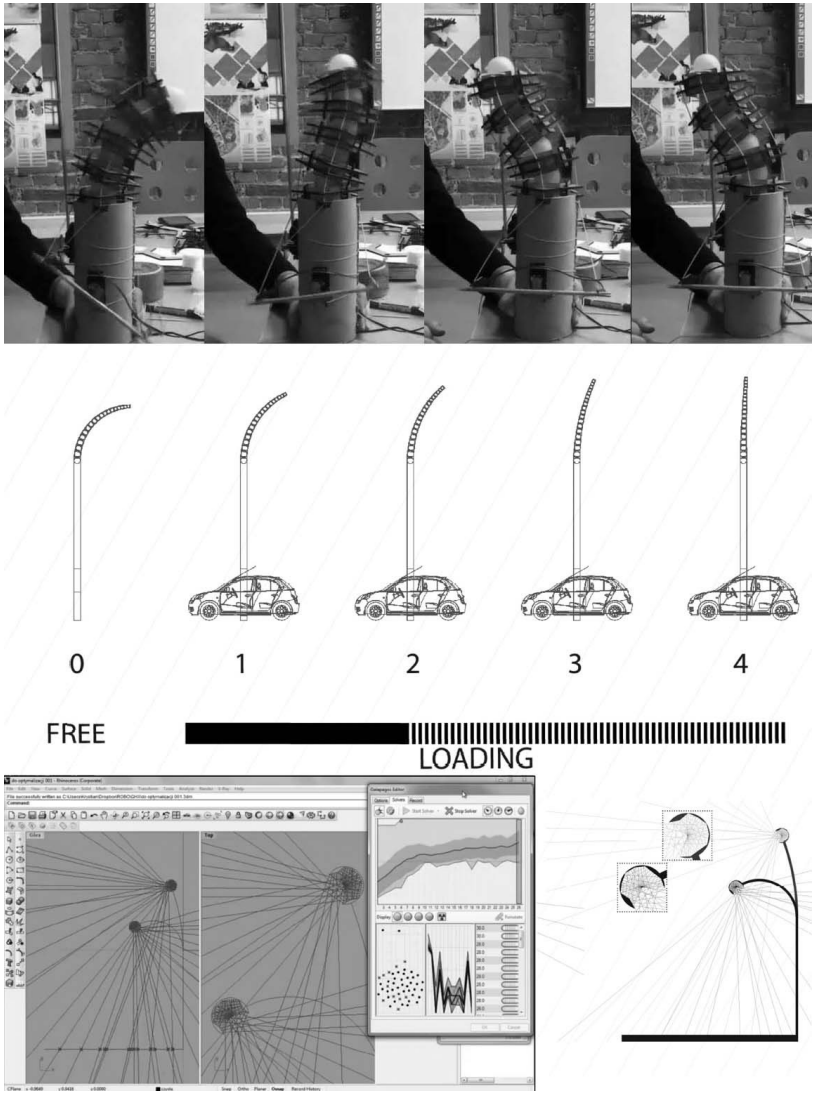


Figure 2
(top) Arduino controlled kinetic model of the initial prototype; (middle) Street light redeployed as part of EV charging network; (bottom) Optimization of the kinetic street light lenses limited potential light pollution.

cally according to the condition derived from an interaction with its environment or with its user. The kinetic transformation of the reCHARGING element was to signify the changing states of use, season, or interaction in some form - converting its initial social or environmental conditions to something 'other'. Designers could develop prototypical, experimental and performative fragment of the larger set. This set of emerging XXI c urban environment become responsive and more akin to nature in its responsivenes.

Today the notion of Architectronics (term Architectronics was introduced and illustrated by authors at the CAADRIA conference in Hong Kong in 2010), derived from consideration of kinematics, mechatronics and robotics in architectural design is discussed. This architectronic practice of design in a networked environment was taken on in multidisciplinary groups in which architecture students worked in collaboration with mechatronic engineering students to produce drawings, computer simulations, animations, and working scale prototype models of selected fragment of their designs. The goal was to bring together students of architecture and engineering to probe the possible application of mechatronics to architectural design practice. Each group of students was to benefit from the approach, knowledge and experience of the other: the architectural students providing the functional, social, cultural and aesthetic framework, and the engineering students providing the basic technical knowledge, with the end project resulting from the feedback and learning which result from the process. For design collaboration a VDS environment was used (*in a Virtual Design Studio [VDS] participants can share their work process, publish crea-*

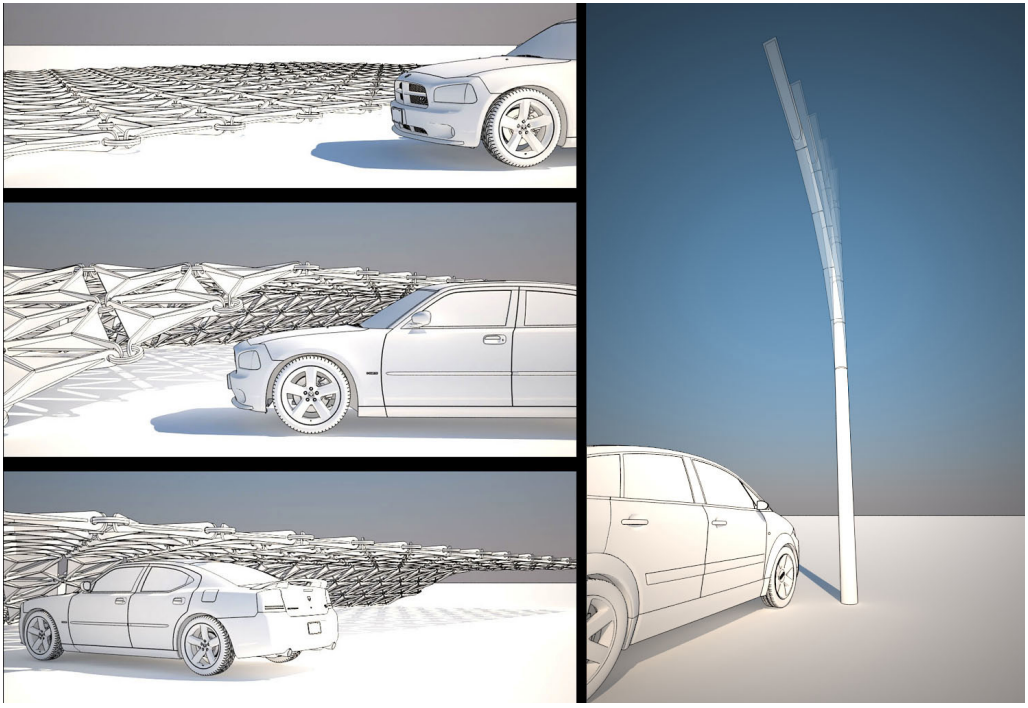
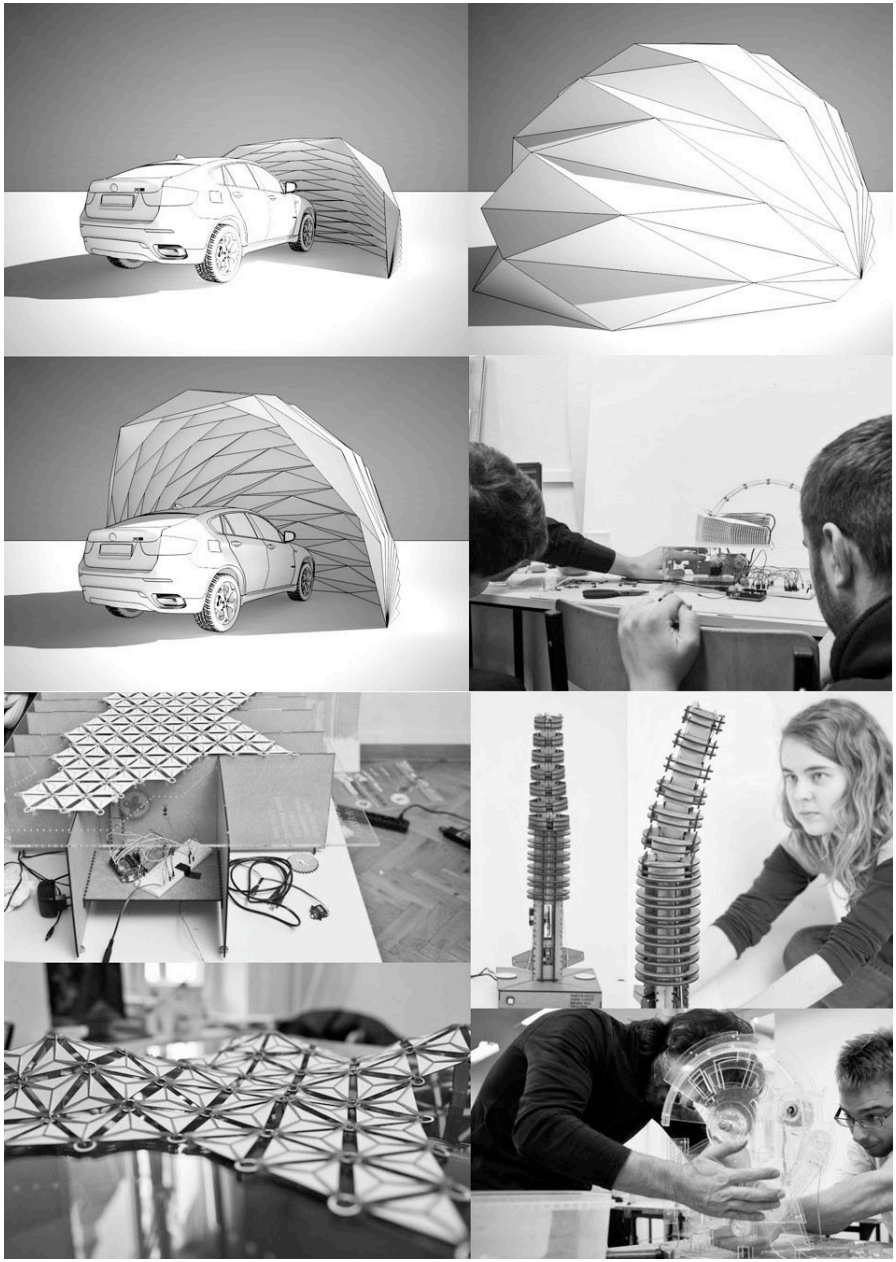


Figure 3
City Carpet, and Kinetic Streetlight projects as part of Interactuve EV charging network contributing to new green and urban landscape of Warsaw.

Figure 4
Interactive EV recharging projects required close collaboration of architecture and mechatronic students and all kinetic designs included performative and wired working models as proof of concept.



tive ideas and critical comments. As collective design studio environment it promotes interaction, common research and conceptualization. Program students, instructors and invited guests can work across temporal, geographic and cultural boundaries. Design here becomes a form of correspondence, as participants often operate outside the limits of familiar ground. When engaged, the VDS method can produce a new social space while redefining the nature of architectural studio and promote distributed design collaboration). For modeling Inventor, SolidWorks or Rhino with Grasshopper, was used as well as Firefly, enabling a direct connection between the Arduino micro-controller and the Rhino/Grasshopper environment. Real-time data flow between the digital and physical worlds and deployment of sensors and actuators in the prototypical model was common.

Among projects developed during three week-long studio workshops, several projects merit special attention: first the City Carpet project situated at the Three Crosses Square in the centre of Warsaw - this dynamically transformable landscape replaced historical but marginalised and leftover urban space. The architectronic system was constructed out of loosely connected planter units and hydraulic actuators. The geometry of it is analogous to medieval chainmail armour where action on any element is progressively transferred to the rest of the system. At the same time loose and flexible connection permits independent modification of the system at the several points concurrently. This mechatronically controlled deflection permits the landscape to be raised to admit an approaching EV. This movement both physically registers the charging process in the urban space and modifies the landscape form in order to celebrate the new technology.

The Kinetic Streetlight project addresses the issue of the visibility of the EV charging spots in Warsaw. With a universal joint structure, the form of the charging+light post can undergo organic type deformation which registers the charging state of the vehicle. The first degree of deflection of the post is seen from a distance; indicating to an approaching driver when the charging spot will be free. As charging time passes, the light post changes its position from inclined to fully erect. The fully erect position signifies full charge and thus availability for the next user.

Project Rakushka (the shell in Russian) is derived from a form of basic car shelter popular in Byelorussia. In its new version it offers not only car shelter, but also retreat for the driver who can relax and isolate himself from urban commotion for the duration of the charge. Made out of breathable elastic membrane material, its surface closes automatically after the car while the additional devices start to emit electronic sounds and images as selected by the user. After charging is complete, the rakushka is automatically raised.

Fragments of one of the ROBO projects are depicted below (Figures 2 to 4). The more comprehensive illustration of the key projects was presented in the eCAADe conference. In the future, work on the use of remote sensors including an exploration of its impact on design is to be addressed increasing the projects' impacts as the infrastructure network is elaborated.

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