REGENERATION OF CONGESTED AREAS BY ROBOTIC URBAN RENEWAL

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ABSTRACT

Dense transport infrastructure areas lack green facilities, they produce annoying noise and they are big energy consumers. As far as there is no free land or space, adding a vegetal covering to existing infrastructures has become a choice in order to get a more pleasant and comfortable environment. Noise barriers are getting spread all over the highways and sometimes they install photovoltaic panels. Is this just a hype or are there real causes? A green acoustic barrier with an energy generator could be interesting for covering the existing urban transport infrastructures. The specific geometry of the infrastructures requires a personalized product. If we measure the infrastructure environment's characteristics, which are humidity, temperature, sunlight and size, we can create an accurate 3D model. This model would be used for various purposes. For instance, it could be a useful tool to design and fabricate the customized prefab acoustic barriers and plant containers. And it would be helpful for adjusting efficiently the future performance of the vegetation and photovoltaic panels. But the insertion of vegetal elements in infrastructure surroundings can be a tough operation. It requires special skills and techniques. Nowadays, those tasks are performed almost manually and they require a big effort. The prefab containers for vegetal elements would ease the robotic assembly on site.

KEYWORDS

Urban, infrastructures, robotic assembly, green covering, energy source

INTRODUCTION and MOTIVATION

Probably, the environments nearby a highway are one of the most annoying ones within a city. Highways and railways often pass through very urban places. This causes several problems related to the traffic, such as noise, pollution and visual and physical degradation. Last decades have been built many bypasses on the peripheries in order to avoid the traffic in the urban core, but the problem hasn't change. Those areas become too many times socially stigmatic, and a renewal it is needed.

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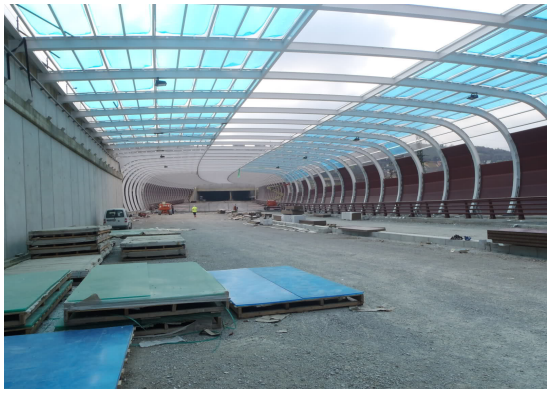
Figures 1,2 – A highway across an urban area with a hospital and apartments behind it.

Traffic is quite unpredictable. That makes that almost every 10 years there is a modification for the improvement of the infrastructure. Any of the solutions adopted on those infrastructures has to be as

lean and flexible as possible in order not to create an extra problem in cases when alteration or adjustment is requested. It can be interesting to develop a dismountable system in order to adjust to different traffic densities. The maintenance of the infrastructure is another aspect to treat. In order to avoid traffic jams or even dangerous situations, the maintenance of the installed devices should be made using robotics.

There are some other reasons related to functionality. Covering those huge linear areas with vegetation is interesting. Obsolete infrastructure areas can be recovered for leisure purposes using vegetation. But structures with a green pedestrian roof or walkable areas could be too heavy for a lean dismountable solution. This is a case for another research type and this paper will focus on the robotic, rapid and lean covers.

The assembly on site must be robotic if we want to achieve a save assembly process. Plus, the robot installed shouldn't disturb or paralyze the traffic at all. The covering system has to be based on prefab modular customized elements and robots should carry and anchor them.



Figures 3,4 –Two types of solution for environmental improvement: A semi covered and a fully covered solution.

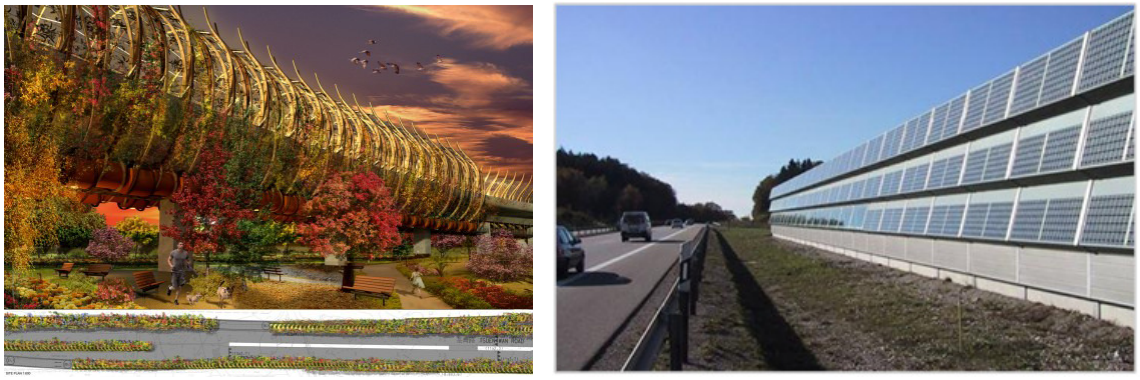
Even more, those prefab containers could embed photovoltaic panels. Transport infrastructures could be used for energy supply purposes. In some regions, the infrastructures (railways, roads, ports) cover up to 45% of the artificial land. The land used for infrastructure represents a too big percentage that is only used for one purpose. Maybe it could be profitable to use them as an energy resource. In order to achieve another purpose for those areas, the installation of solar PV panels can be interesting.

STATE OF THE ART

Earth covered false tunnels combined with buried highways are efficient when there is an inevitable urban need for that. Let's say they are required when there is an urgent necessity. But they're not always affordable. And sometimes, semi-covered solutions are adopted. On the semi covered solutions, the highway is not buried, and the solution can be more economic and easier to make. But an urban barrier is erected. Therefore, environmental improvement measures have to be taken. Inserting some greenery in the wall is a way for getting a more pleasant ambience.

It is maybe quite true that two almost vertical acoustic elements are needed as an acoustic barrier on both edges of the highway. Let´s say that that is a need for acoustic purposes. And then we need a light structure for the covering. There are already some previous examples that serve as an example for this lean structures. If we look for inspiration into natural solutions, we can found the Nongriat root bridges that cover reasonably long spans. But of course, it could take a long time to cover big areas using this natural solution. Besides the anecdotic example, another precedent to study is the light cable structures, such as suspension bridges or Frei Otto's structures. If the load requirement is low, like in this case, this can work

properly. Finally, the geodesic-triangular structure must be taken into account, as a light way for covering long spans. All those light structures could be installed nowadays using robotics. And that's an improvement if we don't want to disturb traffic flow.



Figures 5,6 – Some solutions for environmental improvement around the surroundings of the infrastructures. First, a suggestive image presented on the ``Open International Ideas Competition for Noise Barrier´´ by the Studio Bread. Second, an existing noise barrier with PV panels in Freising, Germany

Normally, acoustic barriers could be placed nowadays easily, meaning that they don't really need earth movement neither a big foundation. Or at least when the barrier is not super seized. One could affirm that the installation of those elements is somehow automated. Those investments ameliorate the ambience conditions of the surrounding environment. But they don't have a direct economic return. Lately, barriers with incorporated PV panels have been developed and installed. These Panels could maybe operate more efficiently if the whole area of the highway was covered.

A good reference in the design of Acoustic Barriers is the ``Open International Ideas Competition for Noise Barrier´´ organized by the of Hong Kong Highways Department on 2009. There are several types of enclosures presented, but as an overall overview, they present a green covering and some energy source.

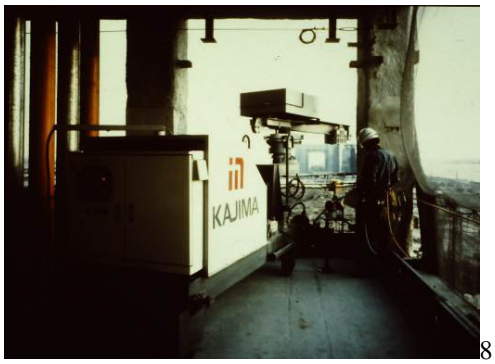
The nowadays robotic technology is applicable for those infrastructure enclosure operations. The panel installing technology could be suitable for erecting the acoustic walls. Then, the robots used for ceiling installation are interesting for all the covering installation. Finally, hanging robots can be practical for the maintenance operations.

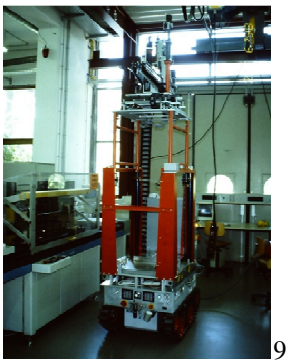
RESEARCH QUESTION and PURPOSE

The purpose of this research is to approximate to a lean robotic system for covering infrastructures with embedded energy sources and vegetation. All the procedures should become automatic or robotized. In the design process, an automatic adjustment plugin could work in order not to re-design all the elements once and again.

But there are some issues to resolve. The foundations are probably the main problem in those cases. Most of the time there is a spare space attached to the highway, but it is not sufficient to work without disturbing the traffic. So the machinery should work longitudinally. If this robotic linear machine was automated enough, it could operate without cutting the traffic. After the foundation is on site, placing the edge- wall, maybe could be a relatively easy operation with nowadays technology.

The enclosure should be assembled without disturbing the traffic, but how could be done? The flying robots may give a clue for how this problem should be resolved. The system should include some protection net when the robot is working on site, of course.



Figures 7,8,9 –Robots placing walls and ceilings. Copyright, Thomas Bock, TU Munich.

Could we install photovoltaic panels in order to have a economic revenue? What about installing them systematically in all highways? If we focus on the basque region, there are 478 km of highways that are 22 m wide. Therefore, almost 10 million sq/m could be covered with panels and greenery, and that would lead to the generation of the 10 percent of the electrical consumption of the region. The panel should be facing south all the time and the module has to be adjusted in all cases, which means that a customization will be required all the time.

Vegetation in the border of infrastructures is difficult to maintain. Could the maintenance of this vegetation be robotic, especially in the places with crooked geometries and bad accessibility, such as dense urban highways and railways?

This article has to be considered as an approximation of a future development. The definition of the mechatronics and kinematics of the robotic machinery will be the next step of this research.

CASE STUDY

In order to deal with a real situation, a virtual case study has been analyzed. The infrastructure is located in the basque region. It is a highway nearby the hospital of Bilbao. The hospital faces directly to the highway, which is not a pleasant situation for the people inside.

The research will try to find a universal solution for a common problem, but adjusted to this specific situation. First, we will have to determine some factors in order to open the development of the product. The final design of the enclosure is shaped for some reasons, such as acoustics, structure etc. This final design should be also defined by the needs the robot will have during the assembly process. Robotic process and design have to be coordinated.

The design has been regulated according to some factors. The main factors that have been analyzed are next:

-Structure: A load-bearing wall is placed on the border of the highway. For covering the highway area, a suspended structure has been proposed. Prefab containers for vegetation and solar panels would hang from the suspended structure. In other words, the cable structure would be the support for hanging the vegetation and the photovoltaic panels. The suction effect should be taken into account in those open covering structures. Rigidity of the horizontal element is needed to disseminate wind force and suction. Though, the semi covered roof lets the air stream to pass through, which minimizes the stresses of the structural solution.

-Rapid assembly possibilities. No material should be manipulated at the site. Special robotic machinery could be designed or readjusted in order to perform the different operations. The most complicated activity will be excavating the trench for the foundation. A longitudinal train type robot should be needed. A truck behind the robot could collect the removed earth. The very same robot could place the foundation and the walls. A robotic crane would operate in order to place the foundation and the vertical panel. The connections could be joined by robots. There is a possibility for placing the foundation and the wall all together. Once the panels are placed, the cable and the net could be installed, using flying robots. How many meters could a robot cover every day this way?

-Economic revenue as a energy source: Sadly, just the environmental benefit by itself may not be attractive for the authorities. The economic viability of installing the PV panels should be taken into account. The hybridization of those areas is an interesting approach in order to find a return of the investment. In order to get more profit, the panels should be oriented properly.

-Customization The road changes constantly its morphology during its route. The highway passes through trenches, bridges etc. Looking for a special solution for each different case would be a tough work. A universal solution has to be designed, meaning that a main generic theme could be found. Then, this generic theme should be customized to offer variations for each case. The different cases need to have a common way of assembly so they can easily be joined together. The construction system has to be assembled with modules. The cross section of the different road types will define which the proper modules are for each situation. As it has been said before, the photovoltaic panels have to be customized to different isolation.

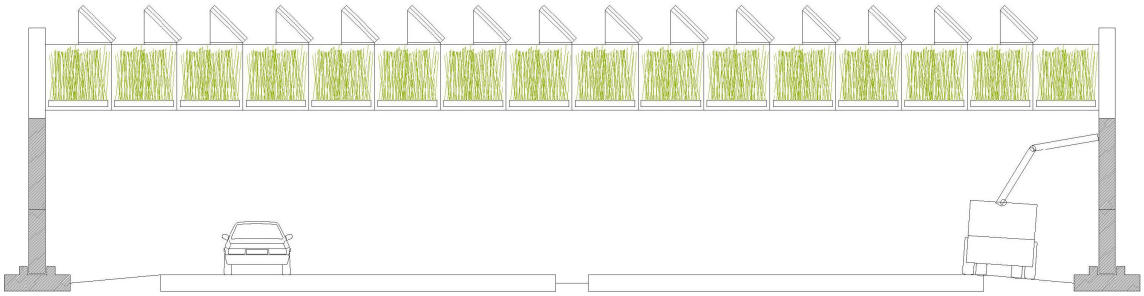


Figure 10 – Cross section of the proposed lean robotic system for covering infrastructures with embedded energy sources and vegetation. Cable structure has been used for the covering. Image by Kepa Iturralde

-Vegetation. There are several reasons to think that vegetation amends our living space and ameliorates our environment's physical performance. Temperature and humidity are balanced and noise is cushioned due to vegetable elements. Green roofs reduce rain water collection and its treatment. Finally, aesthetics of degenerate areas can be improved by implementing vegetal elements. In such a light structure, roots can be a problem both because of its weight and both because their maintenance. What about hydroponic plantation? The earth's requirement could be minimized. It seems quite clear that growing vegetables on those places may not be reasonable. Maybe when the electric car is more developed, the air pollution on the area could be better and vegetables could be produced. Non-edible vegetables should be grown, focused on being just CO2 retainers. A ``vegetal umbraculum´´ with a support structure is created. The 3D model would facilitate to choose the proper vegetation in order to avoid its bad performance. Anyway, depending on the plants used, a net underneath the structure should be installed in order to collect vegetal waste.

-Acoustics: A wall placed on the edge of the infrastructure would work as a noise barrier. The wall's optimal shape won't be discussed, standard solutions will be adopted.

-Material. The material should be adequate to its regions in all cases. If we focus in the basque region for instance, Pine Wood prices have fallen down due to overproduction. The price drop in 6 years has been almost 30%. This leads to think a solution made out of wood. Furthermore, wood is a light material that eases some solutions. First, the foundations of the wall can be smaller and the transportation will be better. Finally, the placement of the prefab wooden wall can be made using lighter robots.

-Sizes of the elements. If a robot is going to operate on site, maybe the elements should have a movable enough seize. The covering should be at least 5 m high from the road. So the supporting wall has to be at least of that high. But moving a 5 meter piece can be tough operation. So the wall could be sub-divided in different elements.

-Recyclable elements. The designed covering could stay for short periods of time. Reciclability of the element is important in the sense that it could be interesting to place the used element in another context. If it is dismounted, the elements should be suitable for another place. We said before that elements should be customized. If we want to achieve that purpose, in the overall design there should be some elements that would be standard and another parts that should be customized for each situation.

-Maintenance. It is not a construction with a roof characteristic, it is not walkable. If maintenance can be done with a hanging robot, weight solicitudes could be minor. The maintenance of the vegetation could be done using robotics. The robot could reach the elements (panels and plant pots). The wire and the net could be removed by the robot too when dismantling of the system is needed too.

Finally, and taking into account all that facts or reasons, a pre-study has been developed. The virtual solution is not focused on its appearance but in its practicality. Aesthetic and basically the form and shape of the constructive system could be moldable.

CONCLUSION

Infrastructure maintenance, renovation and upgrading have to dealt with automated tools in order to ameliorate the nowadays situation. Money and time could be saved. The usuries of the infrastructure will not suffer too many disturbances.The proposal offers an amelioration of the existing environment. To check the performance of the system, more research will be needed. The next step will be to make a scale prototype of the element and a better definition of the robotic machinery.

In order to get the project ahead, the covering will always need public administration support. Or at least their approval or consent will be needed. This research could be extrapolated to another kind of secondary roads, where traffic annoyance is big and there is good sun isolation.

To deal properly the generated energy has to be another aspect to take into account. It will be necessary to sell this energy to an electricity supplier company, so there must be collaboration with them. It has not been analyzed in the possibility to install the system in railways. Though it will be more thjan insufficient, it could be interesting to use the electricity for train electric propulsion.

Will it be necessary a complete automated robotic appliance? The installation system should have different degrees of robotics. It will depend on the economic and technological degree of the context it will applied in.

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