

## MAINTENANCE OF STREET LIGHTS BY CLIMBING ROBOTS IN ALBORZ ELECTRIC POWER DISTRIBUTION COMPANY

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### ABSTRACT

*Dirt and dust reduce the amount of light emitted from the street lamps. In addition the poles of street lamps need to be painted regularly. Manual cleaning and painting of street light are costly, time consuming and cause traffic congestion. Therefore, Alborz Electric Power Distribution Company (AEPDC) and Tehran University have started a joint project in order to design, build and utilize robots that can handle these tasks automatically. In current paper, technical specification and project related information of the robots were discussed.*

### INTRODUCTION

In Iran, installation and maintenance of street lighting systems is one of the responsibilities of electric power distribution companies. Today, majority of lamps which have been used in street lights are either metal halide or high pressure sodium lamps. However, in recent years, other type of lamps like CFL and LED are becoming popular.

Only small portion of dirt and dust which are exist in environment are trapped in optical parts of lighting system. However, if it covers the outer surface of the lamps, the amount of light emitted from the lamps will be reduced. Luminaire Dirt Depreciation is a metric which is used to estimate the impact if dirtiness on luminous intensity of a lamp. Previous studies have shown that between %10 and %60 of light will be lost owing to dirt unless lamps are cleaned periodically. The negative impact of environment on lighting systems is not limited to light loss. Humidity and precipitation can increase the corrosion of light poles metal parts. Therefore, distribution companies paint the poles in a predefined schedule.

Manual painting and cleaning of street lighting system has many disadvantages. Firstly, it is costly and time consuming procedure which needs a considerable manual labour. Secondly, the vehicles which are used in this process can cause traffic congestion and car accidents, and finally, in cleaning process excessive amount of detergent is used which has negative environmental impacts.

Alborz Electric Power Distribution Company (AEPDC) and University of Tehran have involved in an innovative project in order to use robotic technology for cleaning the street lamps as well as painting their poles. There is a contract between AEPDC (client) and University of Tehran (contractor) for designing and making two robots. The first robot can clean the lamps with mechanical

mechanism and the second one can paint the poles. These robots can be carried and utilized by two semi-skilled workers. Furthermore, both robots have a GPS to store the location of light poles as well as a digital camera to monitor the efficiency of cleaning and painting processes. In current paper, firstly, the objectives and limitation of this project was explained. Secondly, the environmental and safety issues which were considered in designing of the robots were mentioned. Thirdly, the technical specification of robots that can assist field crew in light poles maintenance was described. Then, the projects phase which was followed in designing and constructing the robots were set out and finally a few pictures related to the design and application of the robots were illustrated.

### OBJECTIVES AND LIMITATION

The first steps in this project were defining objectives of the project and the identifying technical and environmental limits. Due to the fact that it is not possible to clean a lamp and paint its pole simultaneously, we decided that we need two distinct robots. The first one cleans the exterior parts of lighting system which were made of glass or other transparent materials. However, cleaning the interior parts of lamps was out of scope of this project. The second robot task is painting street light poles automatically.

Since the robots work outdoors, many technical and environmental limitations considered in design of the robot:

- 1- Robot should be portable which can be carried by two workers.
- 2- The robots work in urban areas, rural areas as well as alongside the roads which connects cities, towns and villages to each other. Therefore, robots should work in the presence of direct sunlight, rain drops and wind and in various temperatures. In the region that the robots are used, the temperature can be more than 40°C in mid-summer.
- 3- The cleaner robot cannot be used when the temperature below 0°C owing to the fact that it uses water and detergent to wash the lamps.

### SAFETY AND ENVIRONMENTAL CONSIDERATIONS

Since both cleaner robot and painter robot work in roads and streets, it is crucially important to take safety measures in order to protect pedestrians, cars and robots operators against robots malfunction. These robots work on top of the lighting poles. Therefore, their components including detergent container, water container, paint container and

brushes should be secured firmly. Moreover, robots need mechanical interlocks that prevent robots from falling when the electricity supply is disrupted or electronic modules do not work properly. In addition, the lighting poles become slippery after washing the lamps. Thus the wheels of the robots should provide enough friction for stable movement of the robots. Finally, the electric parts of robots are protected in IP65 cases.

Using paint and detergent are the most obvious environmental aspects of this projects. In order to limit these aspects instead of using strong and harmful solvent, a mild detergent is used to wash the lamps. Furthermore, the painting compartment of painter robot has a special design that prevent paint from being released in environment.

## TECHNICAL SPECIFICATION

The specification of the robots is categorized into three part:

### **Common specification (Both painter and cleaner robots):**

A- Robots can climb up and down poles that their height are less than 15 meters and their shape can be round, hexagonal or octagonal. Diameters of the pole is between 60 mm and 150 mm at the top of the pole and between 150 mm and 250 mm at the bottom of it. The poles are made of iron and are painted in manufacturing process. The thickness of iron sheets which are used in between 2mm and 4 mm.

B- Two operators are assigned to each robots. The responsibilities of the operators are transporting the robots next to the lighting poles, refilling paint, water and detergent containers, charging batteries and protecting the robots against theft.

C- Both robot have indicators that show the battery charge. If the energy stored in a battery is not enough to complete the task, the software that controls the robots prevent the robots to start the process.

D- Both robots are equipped with GPS

### **Specification of painter robot:**

A- When the robot climbs up a pole, it clean dirt and dust from the pole. After the robot reaches to top of the pole, it starts to paint the pole.

B- Robot has an automatic grinding wheel that can remove rusty parts of a pole. This tool play an important role in painting procedure because moisture and pollutants corrode some parts of lighting poles and painting rust is pointless effort.

### **Specification of cleaner robot:**

A- Robot have detergent and water containers. The contents of the containers are protected against dirt.

B- The actuator of the cleaning robot can reach to lamps that have been installed on one meter or shorter arms.

C- The cleaner robot has an interchangeable round brush

that is used to clean the lamps. The roughness of the brush and the force applied to brush have been determined optimally. If the roughness or pressure of brush is more than a predefined range it can damage the lamps and if they are lower than required range, the effectiveness of cleaning will be reduced.

D- Cleaning robot has a camera that capture the image of lamp before and after cleaning. In addition, the robot has a joystick which is used to control the movements of the robot.

E- The robot has level indicators in water and detergent containers. If the detergent and water levels are less than required amount, the robot will not start climbing the pole.

## PROJECT PHASES

This project has been conducted in five phases.

### **Phase 1: Literature review and requirements clarification:**

In the first phase of this project the technologies used in different types of climbing robots were studied. In addition, the climatic information of Alborz province and the types of lighting poles and lamps which are used in Alborz province were obtained. Finally, the safety and environmental aspects of using the robots were examined.

### **Phase 2: Design of robots:**

In this stage different components of the robots including electronic boards and mechanical components were designed.

### **Phase 3: Building robots prototype:**

In the third phase prototypes of the robots were builds based on phase two output. Moreover, the software codes needed for controlling the robots were written. The output of this stage was two robot that could work at the laboratory in controlled condition.

### **Phase 4: Building functional robots:**

In this stage the vulnerable parts of the robots were protected by covers and cases. Furthermore, some fragile components of the robots were replaced with industrial grade ones. The output of this stage are two ready to use robots as well as operation manuals and maintenance manuals.

### **Phase 5: Test of the robots:**

In the final stage of this project is testing the robots in real world condition. In this phase robots are being used to clean the street lamps and paint their poles. Some minor modification will be applied according to the test results.

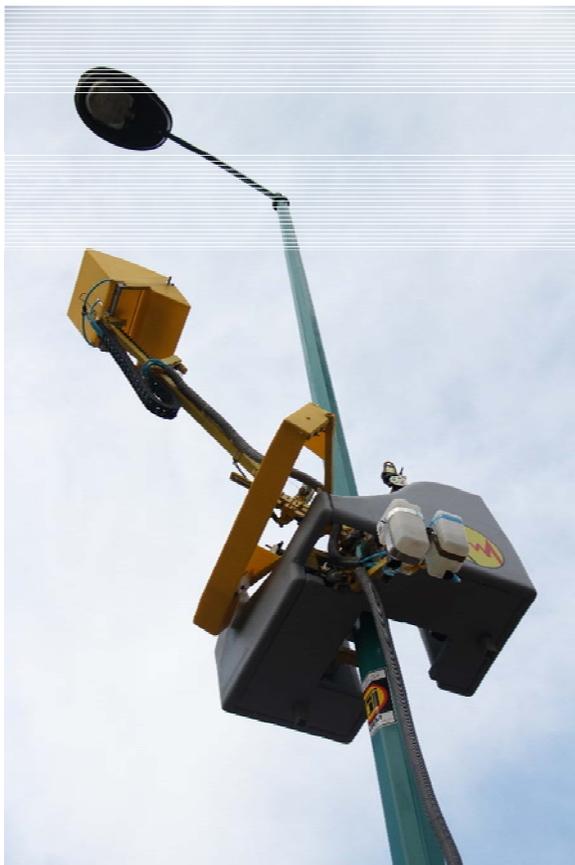
## DESIGNED ROBOT

Painter robot and cleaner robot have been built by Artificial Intelligence and Robotics Laboratory of Tehran University. For further information about the mechanisms which have been used in these robots, please read

reference [1], [2] and [3]. In picture 1 the mechanical design of cleaner robot is depicted. In picture 2 the cleaner robot and in picture 3 the painter robot are shown.



Picture 1: The mechanical design of the Cleaner robot (diagram has been provided by Artificial Intelligence and Robotics Laboratory of Tehran University)



Picture 2: A photo of the robot in the cleaning process (Image has been provided by Artificial Intelligence and Robotics Laboratory of Tehran University)



Picture 3: A photo of the robot in the painting process. (Image has been provided by Artificial Intelligence and Robotics Laboratory of Tehran University)

## CONCLUSION

Alborz Electric Power Distribution Company and Tehran University have started a joint project in order to build and utilize robots that can be used to clean street lamps and paint their poles. We believe that in near future these kinds of robots will be used widely in order to reduce the maintenance cost of network components.

## ACKNOWLEDGEMENT

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