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Wall Climbing Robot, Multi Criteria Decision Analysis, Cleaning Robot, Quality Function Deployment

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EVALUATION OF ROBOTIC CLEANING TECHNOLOGIES: PRESERVING A BRITISH ICONIC BUILDING

Abstract

The engineering building of the University Leicester built-in 1963 has been a British icon for decades now. Applications of Robotic technologies are uprising nowadays, which provides a contingency to manipulate the benefits of robotics for executing challenging and precarious facade cleaning processes. This paper surveys the facade cleaning robotic technologies exist in the market. It exhibits the comparative analysis of four notorious robotic facade cleaning solutions namely Sky Pro, Gekko, BFMR (Building Façade Maintenance Robot) and Sirius_c. The comparison is executed using Multi Criteria Decision Analysis (MCDA) and Quality Function Deployment (QFD) techniques. This study analyses the performance of the robots based on the critical parameters such as water consumption, cleaning efficiency, cleaning dimensions and ease of implementation. Although none of these robotic solutions are implemented off the shelf, some adaptation on these solutions is necessary for the development of robotic techniques work successfully in real time. This paper proposes a hybrid robotic solution combining the vacuum pump adhesion and wheeled locomotion for the effective cleaning of the complex external building structure based on the MCDA and QFD analysis. It highlights the significant future research directions in this field.

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1. INTRODUCTION

After gaining its Royal charter in 1957, the University of Leicester chose Leslie Martin for preparing the master plan for the 9-acre site near the edge of the Victoria Park. Martin was influential in the expansion of university and wanted to use the awkward triangular-shaped corner at the boundary of site for accommodating department of engineering premises (Berman, 2010a). The site was small relative to the space required for the facilities that were meant to be a part of the Engineering building, and this played an essential role in determining the design of the building (Berman, 2010b). Over time, the ability to maintain the condition of the building has become increasingly difficult, and one issue in preserving the state of the building is the cleaning problem. The process of cleaning the external surfaces of the building has been stopped after the health and safety issues that arose during the cleaning operation carried out by maintenance workers. Due to the stoppage of maintenance activities such as cleaning of exterior surfaces, it is becoming increasingly difficult to preserve the condition of this British Icon. The building being Grade-2 has several restrictions on the changes that can be made with the structure in order to keep its historical heritage and iconic image across the world intact.

The recent advancement in technology has opened a wide range of applications for robots. In several countries, climbing robots are currently in use for cleaning high-rise buildings (Breaz, Bologa & Racz., 2017; Zhu, Sun & Tso, 2002) reducing the risk in human workers. For this reason, significant research is carried out in the field of mobile robotics, which has led to the development of climbing robots all over the world (Panchal, Vyas & Patel, 2014). However, most of the robots currently in use are mounted to the building structure and are highly expensive with high maintenance cost (Gudi & Bhat, 2016).

This work seeks to assess the challenges associated with the implementation of robotic cleaning methods. Few market alternatives are compared for their potential implementation for the engineering building based on the information gathered through the literature survey. The evaluation of the robotic technologies is carried out based on some critical parameters for cleaning the façade of the building efficiently. To resolve the façade cleaning problem of the engineering building, symbol of British Icon of University of Leicester, shown in Figure 1, this study explores the possibility of robotic solutions that could help preserve the condition of the building without making significant changes to the structure of the building to retain its historical heritage and iconic look. The remainder of the paper is structured as follows: Section 2 presents the detailed survey of cleaning robots available in the market along with the multi criteria decision making method utilized for selection of the robot. This section also presents QFD (Quality function Deployment) which provides a base for product development. Section 3 presents the proposed system design based on the findings and Section 4 concludes the findings of this paper.

Fig. 1. Engineering Building, University of Leicester, United Kingdom

2. SURVEY ON CLEANING ROBOTS

Manual facade cleaning of buildings is susceptible accident due to the irregular shape of the building, tangled rope, sudden gust, crash against the building, breaking of wire, unfit posture, lousy equipment, and heavy weight. Robots are being widely adopted to reduce the interference of labour for extremely unsafe and dangerous jobs. Climbing robots are useful for a variety of applications including cleaning buildings safely and efficiently. Some cleaning systems are already in commercial use for cleaning buildings (Mahajan & Patil, 2013). The major stumbling block is that these climbing robots are not well suited to complex structures as most systems are mounted to the building and are very expensive to develop, and the payback often takes a long time.

The cleaning method deployed by the robot depends on the type of cleaning required by the building for its maintenance. The wall cleaning is classified as regular cleaning (light soiling), occasional cleaning (medium soiling) and stubborn dirt cleaning (heavy soiling). Typically, robots execute all the above cleaning methods individually but cannot do them together through one integrated system, as not all capabilities can be housed in a single unit for the real-world environment. It is difficult to set up an array of performance requirements for such robots, which adds uncertainty in designing a platform while making optimal trade-offs between competing design criteria (Nansai & Mohan, 2016). The identification and understanding of desirable characteristics of cleaning robots facilitate to set clear technical goals and well-defined design trade-off boundaries (Nansai & Mohan, 2016).

The three functional requirements are 1) locomotion method, 2) adhesion method and 3) actuation mechanism (Guo, et al., 2015). Adhesion system allows the robot to adhere on the surface of the climbing wall/façade properly without falling.

The types of adhesion methods are broadly illustrated in Figure. 2. The magnetic adhesion method is used for walls and surfaces with high levels of magnetic permeability (Nansai & Mohan, 2016; Sahbel, Abbas & Sattar, 2019). This method is not suitable for cleaning non-ferromagnetic surfaces, which reduces its scope for use in wide variety of applications. Pneumatic method allows suction by creating a vacuum between the surface of the robot and the wall, which allows the two surfaces to adhere to each other. Suction cup adhesion works on smooth surfaces, such as glass surface (Rathod, et al., 2017). This method uses suction cups to adhere to the surface and is best used in combination with a leg-based locomotion mechanism (Nansai & Mohan, 2016).

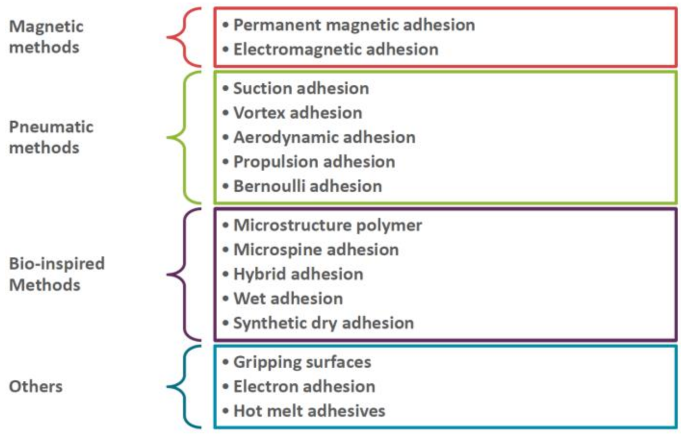

Fig. 2. Types of Adhesion methods used for wall climbing robots

Air leaking is one significant issue with this mechanism, which can reduce the negative pressure that allows adhesion with the wall (Qian, Zhao & Zhuang, 2006). The other drawback of this technology is that it allows slow-moving speeds, which reduces the efficiency of the robot because there is a time delay due to variation in suction pressure in the cups while engaging and disengaging (Nansai & Mohan, 2016). Bio-Inspired Adhesion system is inspired by living organisms that can traverse over vertical surfaces. In this method the climbing behavior of the animals is imitated by the robots (Nansai & Mohan, 2016). This system does not require bulky components to function thus the robots are lightweight. The major drawback in this system is that it cannot carry heavy payloads, thus it provides less productivity.

Locomotion system of the robot provides the mobility and the ability to tackle obstacles in the way of the robot. The locomotion methods can be classified into five major types. as shown in Figure 3. The sliding locomotion mechanism helps the robot to move and operate by a sliding movement, which is straightforward and easy to operate compared to other mechanisms. The sliding mechanism has drawbacks such as limited ability to cross obstacles, low speed, and large components.

The wheeled mechanism allows operation at high speeds with a comparatively low power requirement along with excellent mobility. The major flaw with this mechanism is the ability to tackle obstacles, which is limited due to the manner in the robot, gets unsettled while traversing obstacles (Nishi, Wakasugi & Watanabe, 1986).

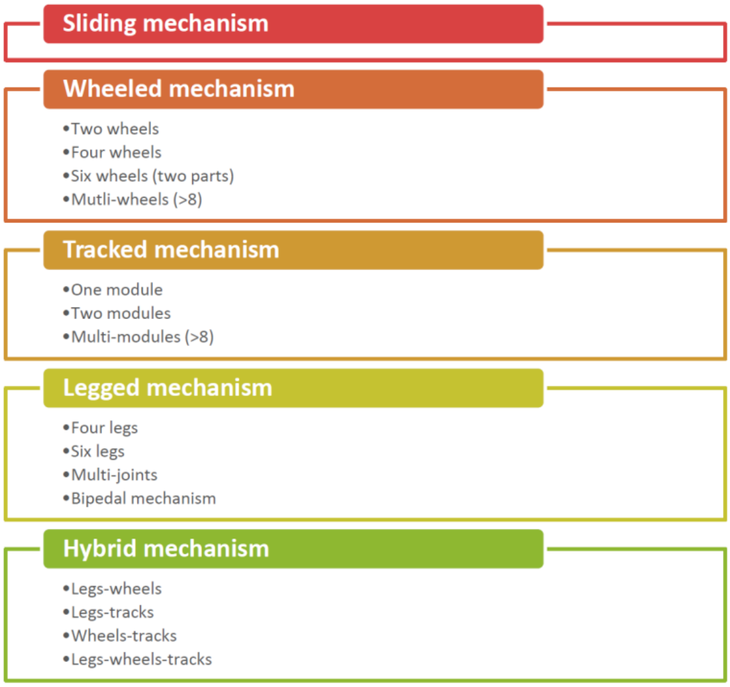

Fig. 3. Types of Location methods available for Wall Climbing Robots

Tracked robots are well suited to soft terrain with impediments because the contact with the ground is considerable. They are slow and require more energy compared to wheeled mechanism robots (Silva, Machado & Tar, 2008). Legged robots have higher mobility in different kinds of structured environments and uneven surfaces (Dissanayake, et al., 2018). Due to the discontinuous movement of the legs, they are relatively slow and consume more energy when compared to the wheeled mechanism. The legged robots have higher stability, robustness, adaptability, flexibility, and efficiency when compared with all the other systems.

Hybrid systems are different combinations of wheeled/legged/tracked mechanisms. They try to combine the advantages associated with all the systems. However, they make the resultant system complex and cumbersome, which make it difficult to operate and manage. In this paper the locomotion methods are compared to assess their suitability for the engineering building. The criteria for comparison are complexity, speed (irrespective of the locomotion method), risk, stability, and suitability. Most common actuation method is by using electric motors, which account to about 90% (Nansai & Mohan, 2016). There are three primary actuation mechanisms, i.e., hydraulic actuators, electric motors, and pneumatic actuators. Hydraulic actuators have one disadvantage, they require fluid reservoir to function, which adds weight to the system, and any fluid leak will lead to failure of the system. Pneumatic actuators require a compressor, which pressurizes air for actuation and this system is useful for large systems rather than compact systems.

The objective of this paper is to identify the suitable adhesion, locomotion and actuation method for facade cleaning on the British icon. It analyses the methods in the direction of proposing hybrid solutions in order to develop effective facade cleaning robot for the British iconic building.

2.1. List of building cleaning robotic solutions

This study focuses the technology discover on the existing robotic solutions in the market for building exterior cleaning. Apart from the mentioned robotic solutions, there many other solutions that currently available or are in development. All these solutions are not discussed because there is not enough information about all the solutions. Therefore, analyzing those solutions without important details would be difficult and prevent a clear picture from emerging from the analysis. However, the list of other available solutions is given in the Table 1.

Some of these robots are utilized for a variety of purposes, but fundamentally they are all climbing robots which are used for different applications. It is noteworthy that most of these robots are not capable of tackling obstacles. The other pattern noticeable is that most them work on vertically smooth façades and not on inclined surfaces. Japan is one country which is heavily involved in developing robotic cleaning. Most of the solutions on this list currently in R&D and are ready for implementation at any level. Most robots use rail-guided kinematic system, which shows that most developed it is the most developed mechanism out of other alternatives.

Tab 1. List of available cleaning robotic solutions (Gambao, Hernando & Surdilovic, 2008)

S. No.	Robot (source/company)	Country of origin	Application	Locomotion (Direction)	Obstacle Avoidance
1	Wall painting Robot by Taisei (Sakamoto, 1990)	Japan	Painting/ coating	Rail Guided (Vertical)	No
2	Tile inspection Robot by Taisei	Japan	Inspection	Cable Driven (Vertical)	No
3	KFR2 by Kumagai Gumi co Ltd (Tokioka, et al., 1992)	Japan	Coating	Cable Driven (Vertical)	No
4	SB Multi Coater	Japan	Coating	Rail Guided (Vertical)	No
5	Gekko	Switzerland	Cleaning	Cable Driven (Vertical)	Yes
6	Sirius_c	Germany	Cleaning	Rail Guided (Vertical)	Yes
7	Vacuum Suction	Japan	Cleaning	Vacuum (Vertical)	No
8	Canadian Crab	Japan	Cleaning	Vacuum cup with Cables (Inclined)	Yes
9	Robosoft	France	Cleaning	Rail Guided (Horizontal & Vertical)	No
10	Fraunhofer Institute robot Leipzig Glass Hall	German	Cleaning	Wheels with Cable (convex)	No
11	Automatic Window Cleaning Robot by Mitsubishi (Gambao & Hernando, 2006)	Japan	Cleaning	Rail Guided (Vertical)	No
12	Comatec	France	Cleaning	Vacuum Cups (Inclined)	No
13	CSIC	Spain	Cleaning	Air suction (Vertical)	No

2.2. Comparison of available robotic solutions

Market available robotic solutions are compared for their potential suitability for implementation for the engineering building. The comparison is based on the specifications and technology used in the robots. Water consumption, cleaning efficiency, cleaning width, weight of the robot and robot dimension are the parameters taken for comparison. It aims to find the efficient robotic solution for cleaning the engineering building of the University.

The renowned robots such as Gekko, Serbot, Skypro, BFMR (Building Façade Maintenance Robot) and Fraunhofer are evaluated. These four robots are identified since they have distinct design features. The Sky Pro robot is designed by skyprocy for cleaning building façade using a cable-driven method. Serbots's Gekko Façade Cleaning Robot is the first commercial robot, which can climb vertical surfaces. The robot can be controlled on vertical surfaces in all directions. The company claims guaranteed high-quality cleaning due to the use of a rotating brush combined with demi-water. Sirius_c by Fraunhofer is supported by crane (cable-driven system), which is installed on the roof. This system is equipped with the advanced sliding frame mechanism, which helps the cleaning unit move in the vertical and horizontal direction in a relatively small area for cleaning work (Elkmann, et al., 2005). BFMR consists of both horizontal and vertically operating robots. The horizontal robot cleans the windows along the horizontal rail. The vertical robot cleans upwards through rail extensors and rail brakes. The rail brakes hold the robot securely, improving the safety of the system considerably (Moon, et al., 2015).

Table 2 presents the specifications of the four robots compared in this paper. Each performance factors are assigned with a score value from 1–5 based on their raw values. The scores are listed in the Table 3 in the next section.

Tab 2. Specifications of the four Robotic Solutions

Robot – manufacturer	Water consumption (L/h)	Cleaning efficiency (m^2/h)	Cleaning width (m)	Weight (kg)	Dimension (m)
Sky pro	300	600	2.4	225–360	3.35 m (overall width)
Gekko	90	400	1.383	79	1.217 × 1.387 × 0.419
BFMR	11	400	1.6	300	1.6 × 1.9 × 0.545
Sirius_c (Fraunhofer)	1.5	200	1.5	200	1 × 1.5

2.3. Multi-Criteria Decision Analysis (MCDA)

Multi-Criteria Decision Analysis, or MCDA, is a valuable tool that we can apply to many complex decisions. It is most useful to solving problems that are characterized as a choice among alternatives. Table 3 shows the raw scores (5-point scale) assigned to each alternative based on the five parameters. The performance comparison depicts that Sky pro robot's performance is ahead of the field with respect to all the five parameters. Next to Sky pro, Gekko robot provides better performance. BFMR robot stands in third position. Sirius_c robot places least in the evaluation queue. Comparison of different parameters helps to determine the best robot in the particular criteria, but it does not help to choose the best alternative solution. However, the limitation of MCDA is the use of assessor's judgement to assign weights and score each alternative. To choose the best alternative, the criterion must be given some context by assigning weights to the importance of each criterion. Weights vary from criterion to criterion due to their varying influence on the operation. Each alternative is given scores based on the listed criterion, and the total weighted score is calculated by applying the percentages to the score to get the weighted score, which is then added to give the total weighted score. The total weighted score helps to decide, which takes into consideration the context behind each comparison criterion. The raw scores indicate that Gekko is ahead of its competing solutions followed closely by Sirius_c. However, the weighted scores can change the pecking order. The weighted score is given in Table 4.

Tab. 3. MCDA scores of the four robots

Criteria	Weightage	Sky Pro	Gekko	BFMR	Sirius_c
Water Consumption	5%	3	5	5	5
Cleaning Efficiency	30%	5	4	4	2
Cleaning Width	15%	4	2	3	3
Weight	10%	2	5	3	4
Dimensions	10%	1	3	2	1
Implementation	30%	2	2	1	2
Total (Raw scores)	100%	17	21	18	20

The weighted scores give a clear picture of the performance of the robots based on the important criteria for the implementation of the robot. Although Sky Pro and Gekko have the same weighted score of 3.15, Gekko is the most developed product in the market and the first robot to climb vertically for cleaning façade systems. Water consumption is given a weight of 5% because it is an environmental concern, but not a technical issue. Cleaning efficiency and implementation have a weight of 30% each due them being the most critical selling points for each of the robots. Sirius_c has a high raw score of 20, but it falls short eventually due to performing poorly in the cleaning efficiency, which is very important for a cleaning robot. Sky pro has lower raw score than Gekko, but it has the most superior cleaning efficiency and closely matches in other areas thus it scores joint-highest weighted score with Gekko. However, due to lack of information and Gekko's market presence makes it a better proposition compared to Sky Pro. The scoring system is developed based on the literature survey and understanding of the technologies developed during the comparison phase earlier.

Tab. 4. MCDA weighted scores of the four robots

Criteria	Weightage	Sky Pro	Gekko	BFMR	Sirius_c
Water consumption	5%	0.15	0.25	0.25	0.25
Cleaning efficiency	30%	1.5	1.2	1.2	0.6
Cleaning width	15%	0.6	0.3	0.45	0.45
Weight	10%	0.2	0.5	0.3	0.4
Dimensions	10%	0.1	0.3	0.2	0.1
Implementation	30%	0.6	0.6	0.3	0.6
Total (Raw scores)	100%	3.15	3.15	2.7	2.4

2.4. Implementation and Adaptation

The literature survey makes clear that the current technologies in its existing state cannot be used to implement robotic cleaning for the engineering building because of the drawbacks associated with each mechanism and solutions available. However, since all the robots compared in this paper use cable-driven rail system in combination with vacuum suction, an adaptation idea is presented without considering the difficulty of execution and load calculations for the idea.

The problems associated with the implementation of robotic solution are listed below:

1. For the building facade area, there is no point above it which can allow the support system of cable-driven robots to be placed.
2. The building being grade-2 does not allow any significant structural changes, which make it challenging to adapt the building for robot cleaning.
3. The problem area has its façade in varying angles both in the horizontal and vertical direction.
4. The frame and the changes in the angle of the façade make it challenging to place the support system, and for robots using housed adhesion and locomotion, it is tough to traverse this area.

The solution proposed to solve the above listed problems is to develop is a temporary platform on which the support system can be placed. The temporary platform should be easily removed after cleaning and is easy to install without any structural changes to the building. The platform should be able to bear load 500–600 kg to bear the weight of the robot and its support system. The support system must have the ability to move forward and backwards or extend so that the robot can clean the surfaces in different depths. The support system must have the ability to rotate on its Z-axis to cater to changes in the angle of the façade. Since designing a robot for a particular purpose is complicated, the system has to be divided into subsystems. The primary subsystems required to execute the desired functions based on the extensive literature survey are Adhesion system, Energy autonomy system, Locomotion system, Actuation system, Sensors and control system, Payload storage (water storage), Cleaning system.

2.5. Concept/Technology Prioritisation using Quality Function Deployment (QFD)

QFD provides a base for product development, and it is not the final step before detailed design execution. The QFD for developing Cleaning robot for engineering building is developed using MS excel, and the four robots considered in this paper are also considered to compare each other to make the case stronger. QFD is large and is presented in two segments. This section of the QFD the customer requirements are presented on the left side of the diagram. The importance of each requirement is marked from 0 to 10 and weight is given for each requirement. On the top side, product characteristics/technical requirements are presented. The right corner presents a comparison of robots in different areas of customer requirements. Black dots represent a strong relationship between the stated requirement and the technical component while calculating this receives a score of 9. Inverted triangles represent weak relation and get a score of 1 and the circles without shading to represent medium relation and gets a score of 3. Empty section means no relation between the customer requirement and technical component. The competing robots are marked between 0 to 5 based on the perceived customer response to the product. The comparison of the market robots shows that Gekko robot can get a high score in almost all areas. The next segment of the QFD presents the calculations based on the relationship matrix.

Figure 4 exhibits a small segment of QFD which calculates the technical importance of each functional requirement based on their relationship with customer requirements. From this calculation, with 17% adhesion is the most important technical component of the cleaning robot. The other significant technical areas include locomotion and cleaning with 11% and 7% respectively. Figure 5 shows the customer competitive comparison between the market robots.

Relationships	
Strong	●
Moderate	○
Weak	▽

Row #	Weight Chart	Relative Weight	Customer Importance	Maximum Relationship	Functional Requirements / Customer Requirements (Explicit and Implicit)	weight	Dimensions	locomotion	adhesion	power source	sensors	electronic	payload	Materials
1		10%	10	9	cleaning		○	▽	○	○	▽	●	●	
2		6%	6	9	semi-automated operation	○		○	●		●	●		
3		8%	8	9	reliable	▽		●	●	●	●	○		●
4		9%	9	9	safe	●	●	●	●	●	○	▽	○	○
5		5%	5	9	portable (not too big)	●	●	▽	○	○	▽		●	○
6		4%	4	9	speed (time taken to clean)	●	●	●	●				●	
7		8%	8	9	Ability to tackle complex design	○	●	●	●		○			
8		6%	5	9	Aesthetics		●			○			○	▽
9		9%	9	9	No major changes to structure	▽	●	○	●					
10		8%	8	9	Prevent damage to the strucutre	○	▽	○	●					
11		7%	7	9	cheap			○	○					●
12		5%	5	9	time to implement			●	●		○			▽
13		5%	5	9	impact resistant	▽			●					●
14		8%	8	3	weather proof			▽						○

Fig. 4. QFD segment 1

Customer Competitive Assesment					
Our Product (theoritical design)	Sky pro	Gekko	BFMR	Fraunhofer	Row #
4	5	3	3	2	1
4	3	3	3	3	2
3	3	3	3	3	3
4	2	4	3	3	4
3	1	2	2	3	5
3	5	4	4	2	6
4	1	1	1	1	7
3	2	3	1	1	8
4	2	2	2	2	9
4	2	3	2	3	10
1	1	2	2	1	11
0	3	4	1	2	12
3	2	4	2	2	13
4	4	4	4	4	14
					15

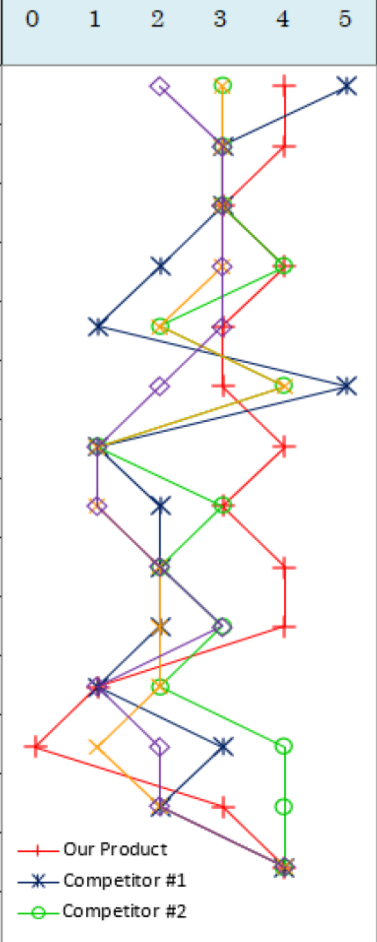

Fig. 5. QFD segment 2

In this comparison, Gekko from Serbot comes out on top by consistently getting high scores in different technical areas. The crucial findings from QFD are:

1. Adhesion system is the most vital technical system of the robot.
2. Gekko from Serbot is the most developed product in the market and is currently the best solution.
3. Locomotion system and cleaning system is also essential for the development of competent cleaning robot.
4. The autonomous operation, time to implement and water consumption of the robots are not critical factors for the development of a competent cleaning robot.

3. PROPOSED SYSTEM DESIGN

The proposed system design consists of the selected solutions for the subsystems based on the MCDA and QFD analysis performed in the previous chapters. In addition to the findings from the QFD analysis, the following tasks involved in the cleaning process of the windowpanes and glass façade in the British icon, such as:

1. Safe navigation over the area of interest
2. Provide necessary adhesion for the robot to adhere to the surface
3. Spray Washing and Wiping liquids
4. Brush, Wash and Wipe the surface to remove the marks and dust in the surface is to be considered.

Further, set of attributes is also considered as constraints in the design of the cleaning robot. The constraints are minimization of cleaning time, slippage, energy consumption, payload, noise level and maximization of adhesion force, area coverage, dust removal, information gathering and safety.

Based on the literature survey, QFD and additional constraints, a simple block diagram and structural design of the proposed cleaning robot system is illustrated in Figure 6 and Figure 7.

Even though, the best choice of adhesion mechanism and system for locomotion would be the vacuum pump adhesion and legged mechanism, observed from the literature, it is proposed to use the wheeled mechanism combined with the vacuum suction adhesion as shown in Fig. 7 for providing the necessary adhesion and locomotion to satisfy the design constraints. The legged mechanism is not considered because of the speed of the mechanism, as it is slow and inefficient. The wheeled mechanism illustrated in the proposed design, can traverse obstacles, and uses 8 wheels and 6 motors for having necessary locomotion. A self-transition mechanism is also proposed in the design where two parts of the robot is connected through an active hinge, so that the robot can negotiate corners and traverse from one pane to another pane.

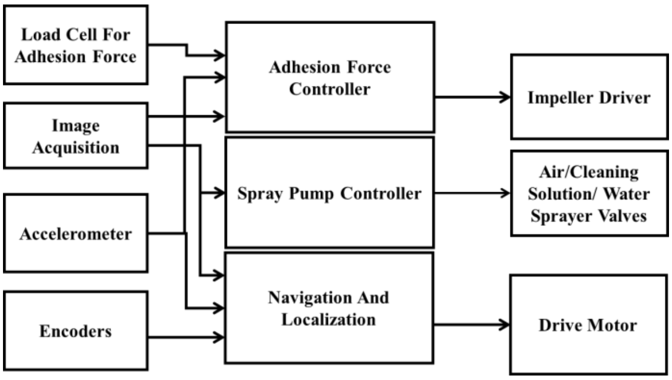

Fig. 6. The proposed system block diagram

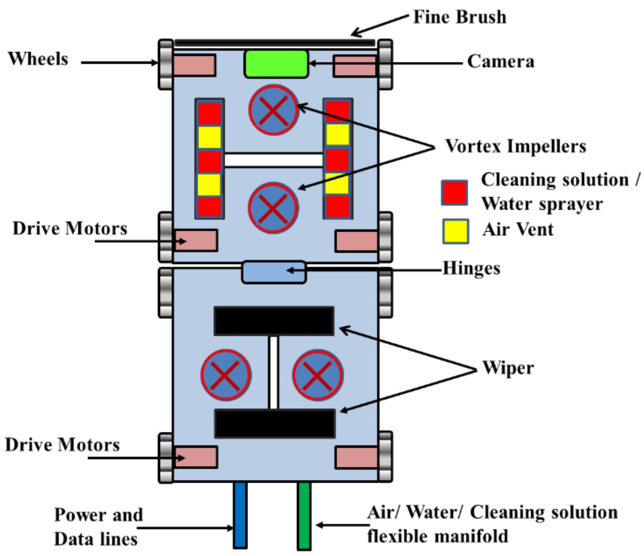

Fig. 7. The proposed model of the Robot

In order to provide the necessary adhesion to the surface, 4 impellers – 2 on either section of the robot is proposed, such that it produces the necessary vacuum suction force for added adhesion, which will increase the safety of the system. Sprayer nozzles for spraying Air, cleaning solution and water is added along with the brushes as shown in Fig. 7. A fine brush is proposed to have at the front of the robot to remove the dust that are fugitive could be swept before cleaning operation. Image acquisition system is also proposed to have in the robot, in order to facilitate the inspection of panes in addition to the cleaning process and to effectively maneuver the area. The robot is planned to be operated from the base where, the pump, power source and controllers as illustrated in Fig. 6. Accelerometer and Load cell sensors could be used for the adhesion force feedback and tilt of the system to control the robot for safety and efficient operations. For safety reasons, a support system where a cable is used to attach the robot to the platform is a must requirement as it mitigates the problem of robots falling due to the failure in adhesion with the surface. This study uses this finding as a baseline for initiating a mission to implement robotic cleaning for the engineering building.

4. CONCLUSIONS

The engineering building of the University Leicester is not currently fit for robotic cleaning due to its complex architecture and restriction on structural changes. The robots cannot traverse the problem area of the building, as the adhesion and locomotion technologies are not capable to safely navigate obstacles like the frame of the façade. Through extensive literature survey, all functional technologies of the cleaning robots are compared in detail. This paper compares the available market solutions and refines a simple system design for developing completely new robotic cleaning system. The most crucial assumption made during this evaluation study is that all technologies would perform in real-life scenarios as they perform in theory and there would be no hindrance from any unknown external factors. The gap in information available is plugged by referring to similar studies and technologies that are like the missing information. Therefore by comparing the available robotic solution through Multi-Criteria Decision Analysis (MCDA) and Quality Function Deployment (QFD) and also considering the tasks and requirements of the cleaning robots, a design prototype is formulated and proposed, which uses the wheeled mechanism combined with the vacuum suction adhesion for providing the necessary adhesion and locomotion. Our future scope of this research is to develop a cleaning robot prototype as illustrated in the proposed system and to investigate its performance by deploying it for Preserving the said British Icon in University of Leicester, United Kingdom.

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