

ASSIGNMENT- CA3 GEN331

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# THE DRONE BASED WALL SPRAY PAINTING METHOD

A report

*Submitted in partial fulfilment of the requirements for the award of degree*

Submitted to

**LOVELY PROFESSIONAL UNIVERSITY  
PHAGWARA, PUNJAB**



*(Purva Thakur, Sumit Kumar and Vikas Arja)*

## **Declaration**

**To whom so ever it may concern**

**We**, hereby declare that the work done by us on “**The drone based wall spray painting method**” is a record of original work for the partial fulfillment of the requirements for the award of the degree, B-Tech, Biotechnology.

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**Vikas Arja**

## **Acknowledgement**

We would like to express our special thanks of gratitude to Prof. Rameshwar Cambow and Lovely Professional University, Phagwara, Punjab, for offering us this course, that has enabled us to get through the deep insight of the topic “The drone based wall spray painting method”. Also, we would like to express our special thanks to all the other researchers who are already working on this project because their works have guided us to the core about some basic concepts and we came to know about so many new things, therefore we are really thankful to them.

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## ***ABSTRACT***

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In today's busy world, people are depriving of a very important dimension and that is time. Therefore, time to time it has become very important to preserve the same so that one could utilize his/her potential and direct it towards something more productive and meaningful rather than indulging themselves in the chaos of spending hours and hours for a single piece of work. For this to correct, a number of scientists and researchers have put forward their way of contribution to help people save their time. So they introduced the whole world with the concept of "machines", anything that reduces human effort and saves the time. So far, we have seen so many impactful changes after the involvement of these machines in our lives. With the development of one machine, the creation of other one had definitely taken place in the past. As, when one machine is created, it also comes up with it's own set of advantages including time saving processes. This all lead to the advancement of the life to some extent and helps in saving a lot of time. But in addition, it also contributes in the development of the other future machine. This is how the cycle works and scientists continue to use the inventions made by other scientists, in

their work to further develop some new machines.

The result is in front of all of us and that is a cool and chill life. But we cannot deny the fact that there are still some of the sectors who are still needed to be uplifted, specially in case of developing countries. As we know that in our country when it comes to civil management, the contractors, builders and painters are still suffering from the challenge of painting the walls of huge buildings, affording the cost for the same amount of paint, maintenance etc., making conventional painting method, a challenge sometimes. For the same purpose, we have come across the idea of making such a drone that would be helpful in painting such a huge buildings, outcasting the need for manual painting technique that is quite hectic, time intensive, labor intensive and most importantly, it is very costly. So, we hope that this invention would bring some advantage to all the people across the nation.

## INTRODUCTION

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This report describes an Unmanned autonomous vehicle ( UAV) called drone, that is equipped with the plan of sending and receiving first and second communication signals to and from the drone. The system consists of signal initialization services that would enable the camera sensors to further pass on the signals to battery region, from there it is passed on to the copters to take the flight. This forms first communication signals. After this is done, the paint dispensing system is activated via second communication signals and the paint is then applied on the wall. The challenges of not only painting simple planar wall but also painting walls with obstructions and patterns, is the motivation for our work. It is also equipped with onboard electronics such as a sensor rig and two computers, a tether having a power and a paint line. In this report, we will cover all the related aspects of the report like survey analysis, limitations of the system, possible solutions to the limitations, real life feasibility or relatability to the public domain, instrumentations, methods and finally the results.

## RESEARCH GAP

Till now only Disney and Zurich have been able to form this kind of drone that is used to paint the walls. In their drone, there are exactly four spray guns mounted in alignment with all the four Pan Tilt Units of the system. As one can imagine the obvious advantage of this design that it saves a lot of time as there are four spray guns working together instead of one. But one challenge to counter in this one is **“orientation problem”**.

If one can visualize the situation, then the question would arise in mind that if the drone is launched at a certain constant distance from the wall then in that case only two of the spray guns would be in contact with the wall instead of all the four and the paint sprayed by the other two spray guns who are not in direct contact with the wall, will go wasted and furthermore it would be sprayed all over the drone itself which would make the drone untidy.

## METHODOLOGY

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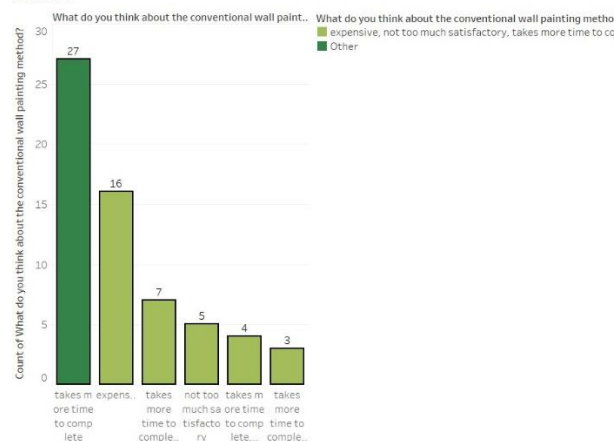
In order to get in touch with the target audience and to know their schools of thought on the idea, we started asking some relatable questions while doing survey. For doing survey, we opted an online survey platform i.e. google forms and collected the responses in the form of counts. Questions that we asked were in

excel sheet into the form of charts having the same responses. Given below are the questions that we asked. People involved in this case are the inventors, the mentors, peers, relatives, public etc.

## Questions

What do you think about the conventional wall painting method?

Sheet 5



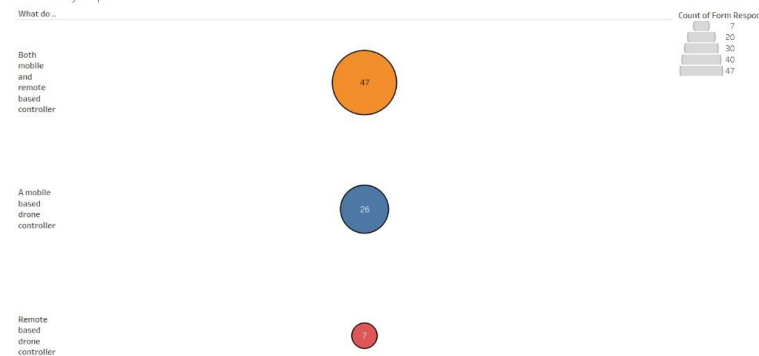
Count of What do you think about the conventional wall painting method? for each What do you think about the conventional wall painting method? Color shows details about What do you think about the conventional wall painting method? (group). The view is filtered on What do you think about the conventional wall painting method?, which keeps 6 of 17 members.

**27 out of 62 people believe that it takes more time to complete.**

the form of Multiple Choice. We are working in the group of three individuals, each of us has done the separate survey on google form and then collected our respective response counts. Then we converted our response counts in the excel form and finally concatenate three of them as one sheet. Further, we converted this compiled

What do you prefer?

what do you prefer?

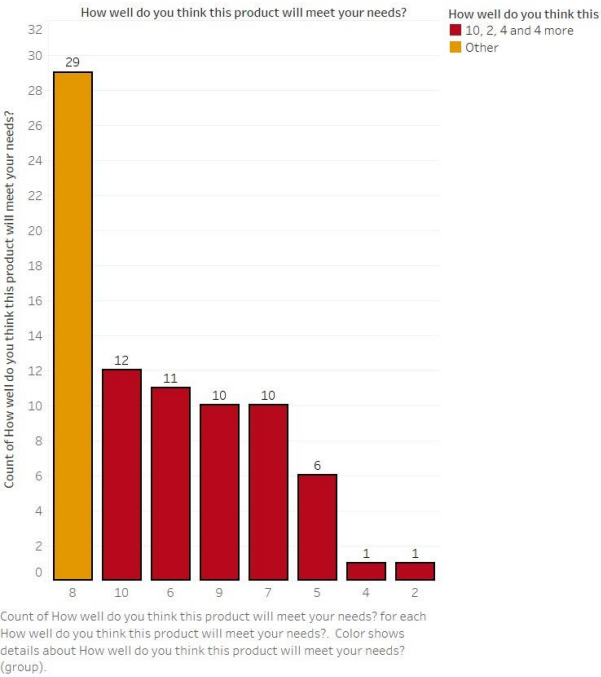


What do you prefer? (color) and count of Form Responses 1 (size) broken down by What do you prefer?

**47 people out of 80 people prefer both mobile and remote based controller.**

How well do you think this product will meet your needs?

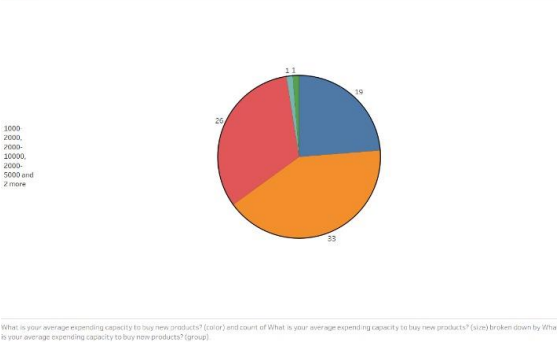
Sheet 3



29 out of 80 people think that this product will meet their needs.

What is your average expending capacity to buy new products?

Sheet 6

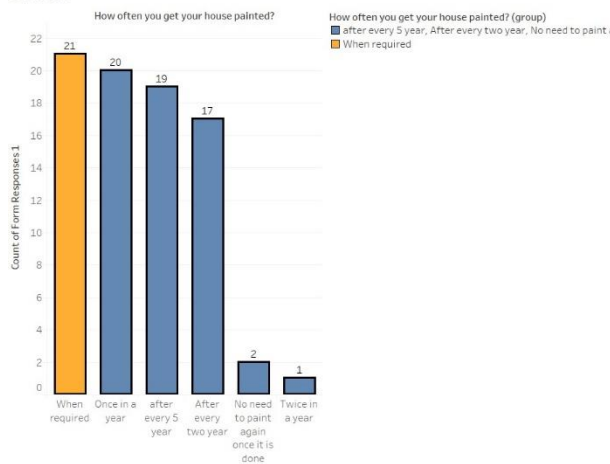


26 out of 89 people have average expending capacity of 1000-2000 that coincides with the rate of our product.



## How often you get your house painted?

Sheet 1



Count of Form Responses 1 for each How often you get your house painted?. Color shows details about How often you get your house painted? (group).

**21 out of 80 people often get their house painted.**

## OBSTACLES AND THEIR SOLUTIONS

- **Objects on the walls can pose a great damage to the drone itself.**

**Solution-** .As already stated that bumping caused due to the objects

on the wall surface can clearly damage the drone. There should be

definitely a defence mechanism against this. For this, the drone is equipped with a single Time Of Flight (TOF) sensor attached to the bottom of the drone in the DJI matrice 100, as a precision altimeter to maintain a constant height, while a multidirectional LiDAR Time of Flight sensor array provides upto 360 degree positional monitoring.

- **Detection of window area and corner regions**

**Solution-** These all can be overcome by Image Processing technique that is installed in the form of a computer vision processing system. A computer visionary processing system is responsible for finding the main wall to be painted, this technique is also known as Region Based Convolutional Neural Networks ( RCNN) technique or simply Image processing technique. If in case the drone encounters some objects like unrequired windows and corners of the walls, this technique helps eliminate these unwanted objects. In this technique, an image of the target wall taken by jetson camera is used as an input, which further passes through the coding platforat

the ground base station as an input. The coding will provide the facilities of image

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processing camera, and it will send the signals back to these cameras after passing the input image through the Convolutional neural network (CNN) of the coding system (mostly for while loops). Those signals are in the form of the class of the image formed by grouping together the areas of similarity in the image. This classed image is actually divided into some regions, so we get multiple regions from this image.

Now, the regions of same colors, textures and enclosure are combined together to form larger regions. Finally these regions then produce the final object locations (region of interest), which are then extracted out with the help of selective search process of RCNN or CNN coding and then it sends the real time communication signals to the drone not to paint that particular object on the wall.

- **If some sections of the wall remain unpainted**

**Solution-** Again the problem can be solved with the help of RCNN technique by recognizing the different texture and color of the unpainted regions and by isolating these regions of interest, ultimately they are painted after the signal.

- **The drone may get crashed after coming in contact with the wall surface.**

**Solution-** In order to get rid of this problem, the drone is installed with Time of Flight (TOF) sensor and Light Detection and Ranging (LIDAR) sensor. The photons and light waves respectively emitted by both the sensors are bounced back to the sensor after striking the wall and based upon the time they take for this journey, the distance to the wall is calculated and is maintained throughout the work.

## PUBLIC ACCEPTANCE

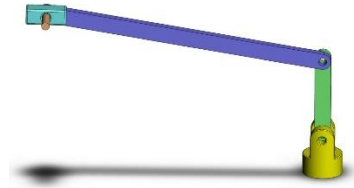
Most of the people during the survey, found our product to be useful. To all the questions we asked, the drift was towards the more of positive side than the negative side. They were excited to practically see the product and were hoping for our invention to become useful for the poor people and the destitutes.

## INSTRUMENTATION

- Platform ( arm, spray gun and Pan Tilt Unit ( PTU))
- Onboard electronics ( sensor rig and 2 computers; one for RCNN technique and the Intel one for depth caculation)
- Tethered offboard ( Power line)

## **PLATFORM**

It consists an arm enabling them to move in all directions, below which there is a Pan Tilt Unit (PTU) above which there is the presence of a rotor also known as the copter. The arm is attached to PTU exactly below it. As the drone consists of four such wings all attached to it's four corners, therefore the drone also consists of four copters all attached to these four wings, that is why the platform is also known as quadrotor or quadcopter, having four rotors.



## **ONBOARD ELECTRONICS**

Onboard electronics consist of a sensor rig that further contains two computers, one computerized camera sensor is used for collecting processed image as a signal from the computer coding for the localization process ( discussed already) and the other one of Intel is used for depth and inertial calculations, which is helpful in actual flying

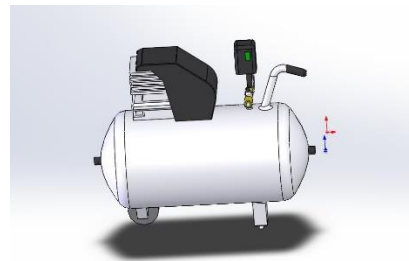
process ( flying to the site of location). They both are connected to each other via Ethernet with the base station (mobile phone, linux OS) where the main coding is done.

## **TETHERED \_ OFFBOARD UNIT**

The offboard unit consists of a high voltage DC/DC converter instead a battery, as a power line that is connected to the platform of the drone.

## **BASE STATION**

Along with the computer system installed with any of the os, ios, linux etc., the base station also comprises the paint reservoir and air compressor which is further with the help of an umbilical cord, attached to the main central component known as spray gun that is exactly mounted over some kind of roller known as servo motor having arduino sensors in it. The reason for installing compressor and reservoir unit at the base station is that they are quite bulky in nature so they may add some weight to the drone making it imbalance during the working process.

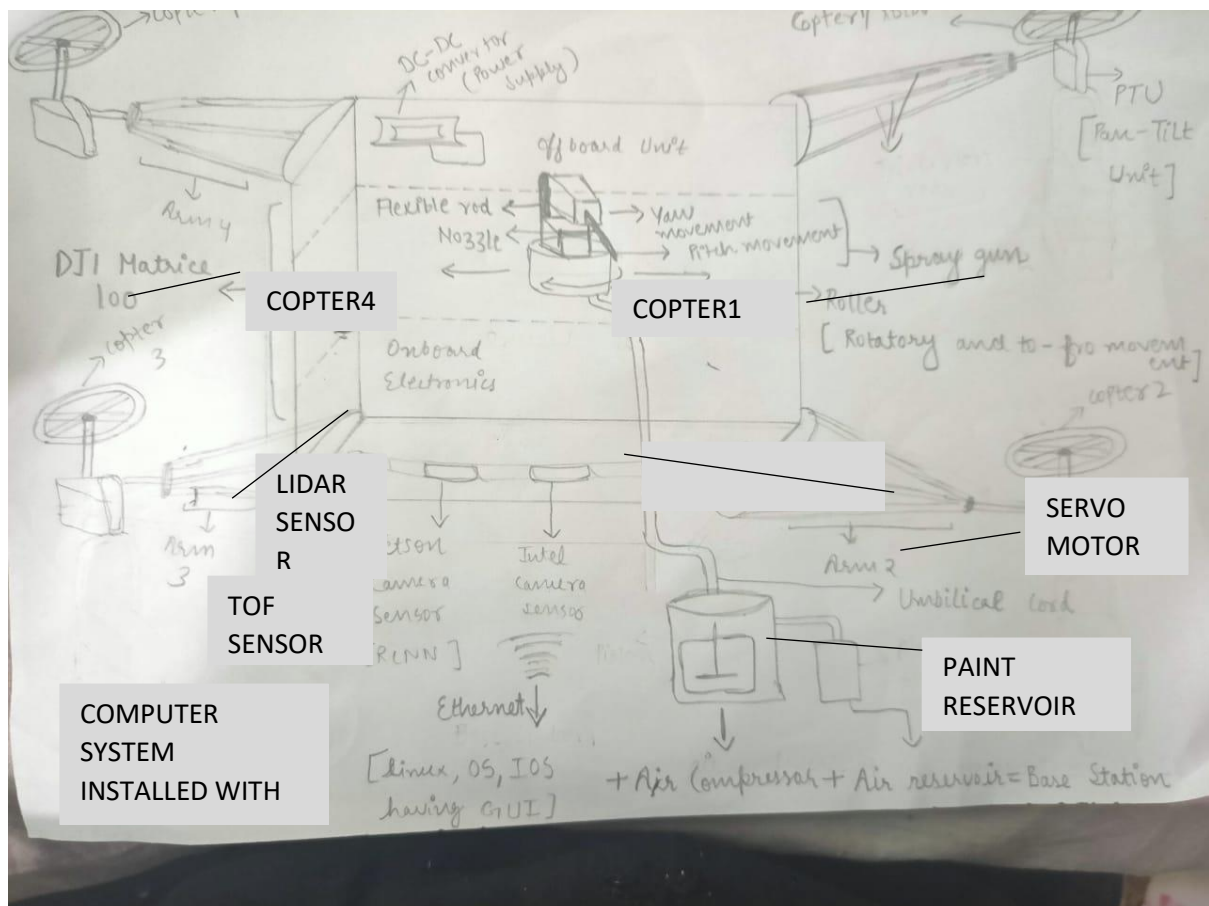


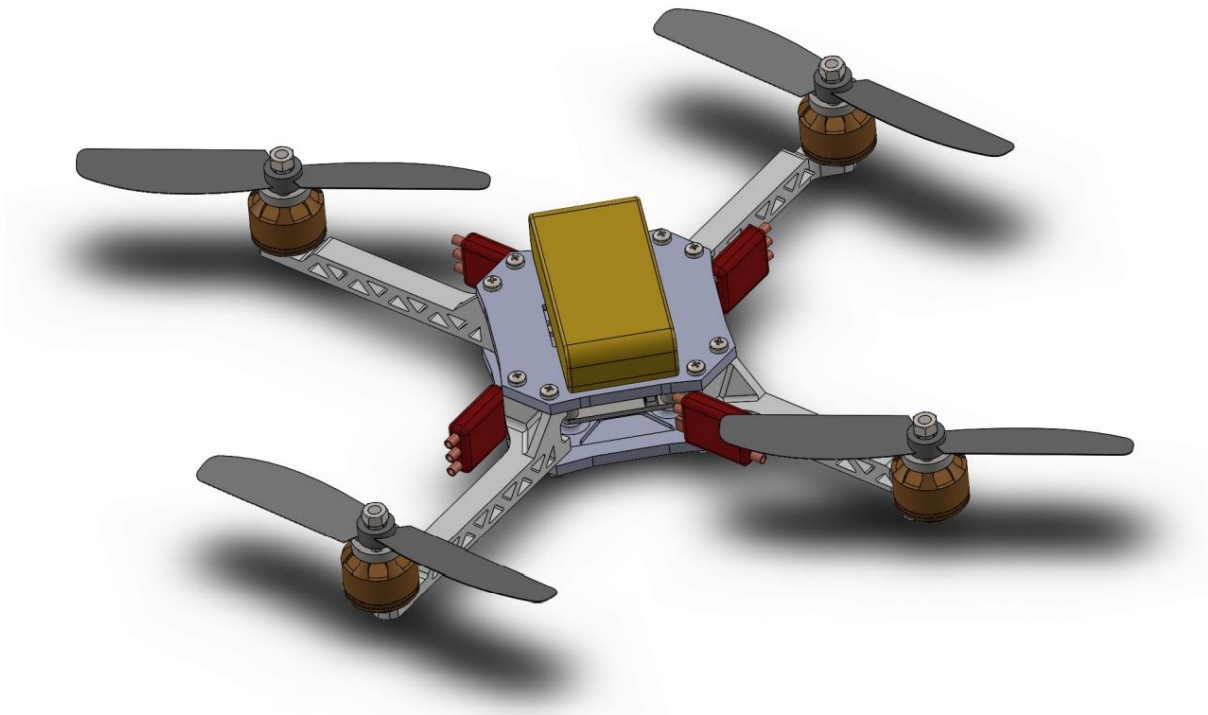
## SOFTWARE

The software mainly revolves around three components; Jetson TX2 camera and Intel Computerized camera and a base station which is usually some kind of OS like Linux Kernel ( but we are looking forward for the android and IOS system to be the base station ). The two computerized cameras of the onboard system are connected to each

other with the help of Ethernet that is further linked to the base station. All the initial acts like image capturing are launched by the user who handles the base station and the former are passed to the onboard camera sensors for further processes. These processes are only executed onboard and not on the base station ( Initialization is done at base station and execution is performed onboard). The base station makes use of the GUI installed in it to launch the processes on both the onboard computers).

## DESIGN





*( Spray gun and base station is yet to be attached, that will besurely done in the final report)*

## WORKING

First of all we click some multiple images of the wall that we want to paint, they should be different from each other like before clicking any image we can simply paint very small region of the wall manually so obviously it is going to be different from the previous image on which there was no manual paint applied and then we send these images to the computer system installed at the base station simply via the phone. The computer system is connected to onboard camera sensors via Ethernet or wifi. Then we perform some special python coding on this computer system that is going to compare all these multiple images as input and it will ultimately produce one resultant image as an initialization signal for the camera sensors.

Earlier we were thinking of using special image processing cameras whose microprocessors are already coded to perform image processing technique but as they cost a lot so that is why we replaced them with normal image capturing cameras and thought of doing the coding part all by ourselves on python platform. So we can say that the coding that we are doing equals to the function of image processing cameras because the resultant image we are getting is image processed one.

Then, this processed image is passed to the onboard camera sensors as an initialization primary (first) communication signal that

further communicates with offboard DC-DC convertor part. It further transfers the signal to all the four PTU units of the platform. From there the signal is further passed to all the four copters, as a result they are activated and start rotating and the drone ultimately starts flying to the wall.

Now as it is approaching the wall, it should definitely maintain some constant distance from the wall in order to avoid

crashing of the drone. For this to happen, it is also equipped with T.O.F. and LiDAR sensors. T.O.F. sensors emits some photon particles that strike the wall surface and bounce back to the same sensor after striking with the wall. The time calculated by the particles to reach back to the sensor is known as T.O.F.. So, the distance to the wall is calculated by analysing the T.O.F. profiles of the particles and the same is maintained throughout the work. Same is in the case of LiDAR sensor just the difference is that, light waves are emitted instead of photons.

Now the user at the base station is required to activate the air compressor unit by adjusting the pressure valves of the air reservoir attached to it. The air is then passed from the reservoir unit to the air compressor unit, the pressure and the contaminants present in the air is controlled by filters present on the surface of the outer chamber of the compressor. The air is then passed to the interior of the outer chamber. Now, the air pressure causes the piston present inside the outer chamber to move down all the way to the inner chamber known as paint reservoir, where the actual paint fluid is present. Now, under the pressure put forward by the piston the paint fluid moves out of the air compressor and is passed on to the umbilical cord attached to it.

Now, the challenge comes. How to make this umbilical cord pass fluid to the spray gun as the upthrust of the fluid is negligible as compared to the downward gravitational pull. Moreover there should be some sensing system rather than just the normal pipe because spray gun senses signal language instead of just the simple fluid. Moreover, the system is just like a string attached to a kite that is being swayed away by the wind force also. So in

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order to prevent all these effects, we have attached some sensors in the inner wall of the umbilical cords namely, accelerometers ( to pump up the liquid to the spray gun), barometer ( to measure pressure inside the cord) etc. As a result, the liquid gains much upthrust enough to reach to the spray gun successfully. All the sensors and their interactions with the paint fluid forms what is called as secondary communication signal that can be detected by spray gun as soon as it reaches there. Now, the liquid moves to the filler of the spray gun as the umbilical cord is perfectly aligned with the spray gun.

But in order to rectify the disadvantage of Disney's and Zurich's drone system, that is in order to increase the efficiency of single handed spray gun, we have mounted over the top of some roller kind of structure that is fixed to its axis. It is known as servo motor that enables the spray gun to move from left to right in order to increase its appendix area so that it can paint as much as area as possible. Not only this, the axis rod to which the motor is attached, is very flexible in nature because it can move up and down also, making the servo motor also move up and down. As a result, the spray gun attached to the motor can also move up and down along with it.

DJI maticr 100square is nothing but a kind of square shaped structure used to internally and externally attach all the other components of the drone and the DC-DC converter that we are using, helps in increasing the shelf life of the normal battery whose voltage potential is around 6-7 volt on an average, so if the converter is installed in addition with the normal battery, the former can make the latter's potential upto 14-16 volt.

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## **RESULTS AND DISCUSSIONS**

The experiment is yet to be performed in outdoors, so results cannot be judged right now.

## **CONCLUSION**

This report has described an Unmanned Autonomous vehicle (drone) that reduces

the need for scaffolding and ladders and other utilities, making the system time effective, labor effective and most importantly cost effective, that was quite hard to observe in case of conventional painting method. The whole system revolves around two way communication signals, first communication signals making the drone fly to the site of painting and second communication signals making the drone ultimately paint the wall. In this

report, we have provided effective solutions to almost all the problems like supplying paint via umbilical cord, the whole setup at the base station, coding

challenges, recognising what areas not to paint etc. and we can possibly implement it in the form of fully fledged drone.

### **Participation index**

**Purva Thakur-made report and searched reference material**

**Sumit kumar- made 3D- model of the design**

**Vikas Arja- Provided more reference materials.**

### **REFERENCES**

- **Anurag Sai Vempati, Mina Samir Kamel, Nikola Stilinovic, Inkyu Sa (2018).** PaintCopter: An Autonomous UAV for Spray Painting on 3D Surfaces: **ResearchGate**, (99), [10.1109/LRA.2018.2846278](https://www.researchgate.net/publication/32846278)



