Feedback Control Analysis of Painter Robot

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The application of painter robots is a useful component to modern painting. The robot is neither limited by stamina nor needs any protection from fumes like humans do. The robot's main purpose is in jobs that require large tedious painting on difficult surfaces. For example tall smokestacks that require a human painter to have a safety harness can instead be done by a tethered robot that can easily be replaced compared to a human life. The goal would be that the robot can complete certain sections without any guidance or overseeing other than replacing paint and the occasional repairs.

The objective of this specific paint robot is to possess the capability to spray paint a design any continuous vertical exterior wall such that the top of the wall is no less than one foot wide and the height of the wall is no larger than 30 feet (the approximate range of bluetooth communication). The design will have no more than three colors and a resolution smaller than 3 square inches. This will be achieved through a two component system. The first being the ArtBot, which sits on top of the wall. The ArtBot controls the horizontal and vertical movements of the painter robot as well as when the painter robot should spray any specific color. Both the painter and the signaler robots have will have an ESP32 onboard; each robot will communicate to the other via bluetooth.

The robot on the wall's face, PaintBot,will be designed to hold three colors of paint - therefore three cans of spray paint. Due to this constraint, the robot's dimensions will be approximately 10" x 9" x 5". The weight of the cans will account for about 2.5 lbs of the robot's weight, while the chassis, electronics, and cable bring the total to roughly 8 lbs. The robot on the top of the wall, the ArtBot, will weight approximately 10lbs. The robot has two degrees of freedom: the vertical and horizontal axes. This allows for complete coverage of a flat surface. Vex Omni wheels will be used to allow the PaintBot to easily roll down the wall while it paints and shift left or right as it changes positions. We plan to include a few sensors to provide the robot with more direction and precision. An ultrasonic sensor will be on the front and back of the robot to prevent the robot from hitting the ground and also an ultrasonic sensor to the bottom of the robot so that if it gets blown off the programmed path, then the robot will stop painting. There will also be an emergency stop button on the both PaintBot and ArtBot for safety purposes. Major components include a (5V and 12V)battery, stepper motors, ESP32s, sensors, and servos.

The PaintBot will paint the wall between 1ft/sec to +1ft/sec. For the artist, the payload consists of the weight of the cable(1lbs), the weight of the paintbot(5lbs), and the weight of the paint(1.9lbs) totaling to 8 lbs. The artist will have control of 3 motors (raising/lowering robot and horizontal movement), drawing power from a 12V battery. The PaintBot will have three servos, one for each paint can, as well as range sensors and an arduino which will draw power from a 5V battery.

The painter robot will need to overcome a few key challenges as it navigates the wall on which it is painting. Firstly, the subsystem containing the spray paint cans (PaintBot) will be suspended from up to 6 feet from the ArtBot. Since the PaintBot is suspended by two flexible cables as the ArtBot moves laterally, the PaintBot will be susceptible to swaying side to side, parallel with the plane of the wall. The software must account for these errors and this will likely be a challenge as we develop the robot. Additionally, the three spray paint cans are positioned in a row. When spraying the paint, the center of each flow will be located about 1.5 inches from each other. This will force the PaintBot to move up or down to select the color as it navigates each column it paints.

Our painting robot has two main closed loop actuators: the cable drum and the driving base on the ArtBot. The cable drum is used to reel in and out the cable that holds the PaintBot. It uses a stepper motor to count ticks to accurately determine the vertical coordinate that PaintBot needs to be on. The upper and lower cans are then compensated for their distance away from the origin. A PID controller will be used to ensure that the drum maintains the coordinate for a specific amount of time until the PaintBot finishes its purpose as well as dealing with the change of weight as the paint begins to deplete. The geared motors for the ArtBot base will have a gear reduction which will allow for precise control of the PaintBot. Additionally, there is a focus directed towards torque as a result of the added counterweight on the ArtBot to avoid being pulled down. The wheels for ArtBot also have encoders to allow accurate horizontal movements along the “columns” in our established coordinate system.

Currently, many painter robots are targeted towards painting businesses. These robotic arms can be operated by the workers that used to paint walls and prevents said worker from spending the day twisting and bending. The addition of robots to the industry could be caused by the increase in minimum wage. With the addition of robots, painting can be done more efficiently, and for a lower cost in the long run. For painting the outside of a building, robot arms are placed on a platform similar to a window washer. However, building a robot of this kind can be expensive. The ArtBot and PaintBot will dramatically improve on the cost of this kind of robot, therefore making it more accessible to more companies.

Our design utilizes a 5V and 12V battery for power supply. Both the PaintBot and ArtBot each have their own battery. One key risk we must avoid is allowing excess spray paint in the robot’s environment to contaminate the electronics of each robot. When in operation, it might be recommended to stand away from the wall on which the robot is painting. The robot could be suspended quite high from the ground and may fall in the unlikely event of a malfunction.