~~Method for spray painting the external walls of a building with a lightweight six axis robotic arm coupled with a 3D camera, and a spray nozzle on its end effector; and mounted on a mini-gondola with the mini-gondola hoisted by a motor-drive pulley system traversing along a set of twin-rails located on the roof-top of the building.~~ **System and Method for Spray Painting External Walls of Building**

FIELD OF INVENTION

The present invention relates to a system and method for spray painting, and in particular, a system and method for spray painting the external walls of a building with a lightweight six axis robotic arm coupled with a 3D camera, and a spray nozzle on its end effector; and mounted on a mini-gondola with the mini-gondola hoisted by a motor-drive pulley system traversing along a set of twin-rails located on the roof-top of the building.

SUMMARY

The present invention provides a lightweight six-axis robotic arm, coupled with a 3D camera, and a spray nozzle on its end effector, is seated on a mini-gondola to carry out spraying painting on external walls of a building.

The use of an industrial PC (personal computer) located within the mini-gondola to control a motor-driven pulley system to hoist and lower the mini-gondola to locate the vertical location of the robotic arm (seated on the mini-gondola) for the painting process to be carried out.

The controlling motor of the pulley system that hoists and lowers the mini-gondola in parallel to the external wall of the building to be painted, is located within the mini-gondola.

The mini-gondola hangs on a motor-driven pulley system that traverses along a pair of rails, guiding the mini-gondola/robotic arm to travel along the linear distance (x-axis) for the painting process to be carried out.

The use of four vacuum suction cups mounted respectively on each linear actuator to secure the mini-gondola to the wall when the robotic arm makes a 'stop' for the painting process to be conducted; the suction cups are controlled by an industrial PC (personal computer) located within the mini-gondola.

The use of three ultrasonic distance sensors mounted on each linear actuator on the mini-gondola to measure and manage the distance between the mini-gondola and the wall that is to be painted ; the distance measured will then be fed back to an

industrial PC (personal computer located on the pulley system that hoists the mini-gondola) which controls the distance between the mini-gondola and the wall to be painted ; four vacuum suction cups on the mini-gondola will then be activated to secure the mini-gondola to the wall.

Once the mini-gondola is 'secured' to the wall, a 3D camera mounted on the robotic arm will be activated to scan the wall area to be painted ; a software program will calculate the trajectory path of the paint spraying motion for the robotic-arm to carrying out the paint spraying action.

The use of a collection hood covering over the paint spray nozzle to collect any paint debris and paint fallouts during the paint spraying process.

The use of a pair of facade protection wheel (6) on the mini-gondola to cushion any impact of the mini-gondola made on the facade of the wall to be painted.

The use of an Industrial PC (personal computer) to control a controller located on the roof-top to monitor the paint level within the paint container to ensure that paint availability is maintained.

The use of water weight for counter balancing on the motor-driven pulley system.

BRIEF DESCRIPTION OF DRAWING

Figure 1 illustrates a system in accordance with an embodiment of the present invention.

DESCRIPTION

Figure 1 illustrates a mini-gondola in accordance with an embodiment of the present invention. A lightweight six-axis robotic arm (2 ~~in Figure 1~~) is adopted to paint ~~the~~ external walls of a building with a paint spray nozzle (1 ~~in Figure 1~~) mounted on the robotic arm's end-effector to spray the paint onto the walls. The robotic arm is mounted on a mini-gondola (10 ~~in Figure 1~~) and hoisted by a pulley system with the controlling motor located (9 ~~in Figure 1~~) within the mini-gondola, while another set of motor located on the pulley system (11 ~~in Figure 1~~) at the roof-top end drives the mini-gondola to traverse laterally on a set of twin-rails on the roof-top of the building. The pulley system raises and lowers the mini-gondola in parallel to the external wall of the building to be painted, spray painting the wall in a vertical manner from top to bottom, column by column.

1. The lightweight six-axis robotic arm (2~~ in Figure 1~~)

The six-axis robotic arm is to be lightweight, and is coupled with a 3D camera and a spray nozzle (airless paint sprayer) on its end effector. The 3D camera mounted on the robotic arm scans the wall area (approximately 1.2m by 1.2m) to be painted; a software program will then calculate the trajectory of the paint spraying motion for the robotic-arm to carrying out the paint spraying action.

The robotic arm is controlled (through a RS422 cable, TCP/IP) by an industrial PC (personal computer) (5~~ in Figure 1~~) mounted within the mini-gondola.

2. Adoption of mini-gondola (10~~ in Figure 1~~)

A specially designed mini-gondola, hoisted by a motor-driven pulley system with the controlling motor of the pulley system within the mini-gondola, is used to seat/house the robotic arm to carry out the painting of the external wall of a building. Four vacuum suction cups (7~~ in Figure 1~~) mounted on the mini-gondola helps to secure the mini- gondola to the wall when the mini-gondola/robotic arm makes a 'stop' for the painting process to be conducted. To have further securing of the mini-gondola - prevention of swaying motion - a tow line attached to the mini-gondola is used to secure the mini- gondola to the ground.

An onboard controller (4~~ in Figure 1~~) mounted on the mini-gondola manages and controls the distance between the mini-gondola and the wall to be painted. The measured distance is fed from the onboard controller to the Industrial PC (personal computer located within the mini-gondola), which then activates the robotic arm to start the painting process.

3. Motor-driven pulley system with controlling motor within the mini-gondola, and Industrial PC for roof-top controller

The controlling motor (9~~ in Figure 1~~) of the pulley system that hoists and lowers the mini-gondola in parallel to the external wall of the building to be painted is located within the mini-gondola. An Industrial PC (personal computer) located within the mini-gondola controls this controlling motor, hoisting and lowering the mini-gondola in the vertical height position (y-axis) to locate the position of the robotic arm (seated on the mini-gondola) for the painting process to be carried out. The Industrial PC also controls another motor (11~~ in Figure 1~~) that drives the mini-gondola to travel along

the linear distance (x-axis), traversing along a set of twin-rails located on the roof-top of the building.

Water weight (12 ~~in Figure 1~~) is used to counter balance the pulley system on the twin- rails.

4. The control (monitoring of paint container level) and discharge of the paint sprayed from the nozzle.

The paint will be sprayed onto the wall with an airless paint sprayer mounted on the end- effector of the robotic arm. A collection hood covering over the paint spray nozzle is used to collect any paint debris and paint fallout during the paint spraying process. An Industrial PC (personal computer) is used to monitor the paint level within the paint container to ensure that paint availability is maintained.

5. The building facade painting sequence

The painting sequence will be from left of the building and moving towards the right as the motor-driven pulley system transverses itself in that direction. The spray painting on the wall will be in a vertical manner from top to bottom, column by column; once each column is being painted, the motor-driven pulley system will traverse to the right and make another ‘stop’ to paint the next following column.

6. Ground Controller

Through RS422 or RS485 (long distance serial communication), the industrial PC is also controlled by a remote electronic controller to allow the control of the motor-driven pulley system at the ground level.

CLAIMS ~~(11)~~

~~(1) A lightweight six-axis robotic arm, coupled with a 3D camera, and a spray nozzle on its end effector, is seated on a mini-gondola to carry out spraying painting on external walls of a building.~~

~~(2) The use of an industrial PC (personal computer) located within the mini-gondola to control a motor-driven pulley system to hoist and lower the mini-gondola to locate the vertical location of the robotic arm (seated on the mini-gondola) for the painting process to be carried out.~~

~~(3) The controlling motor of the pulley system that hoists and lowers the mini-gondola in parallel to the external wall of the building to be painted, is located within the mini-gondola.~~

~~(4) The mini-gondola hangs on a motor-driven pulley system that traverses along a pair of rails, guiding the mini-gondola/robotic arm to travel along the linear distance (x-axis) for the painting process to be carried out.~~

~~(5) The use of four vacuum suction cups mounted respectively on each linear actuator to secure the mini-gondola to the wall when the robotic arm makes a 'stop' for the painting process to be conducted; the suction cups are controlled by an industrial PC (personal computer) located within the mini-gondola.~~

~~(6) The use of three ultrasonic distance sensors mounted on each linear actuator on the mini-gondola to measure and manage the distance between the mini-gondola and the wall that is to be painted ; the distance measured will then be fed back to an industrial PC (personal computer located on the pulley system that hoists the mini-gondola) which controls the distance between the mini-gondola and the wall to be painted ; four vacuum suction cups on the mini-gondola will then be activated to secure the mini-gondola to the wall.~~

~~(7) Once the mini-gondola is 'secured' to the wall, a 3D camera mounted on the robotic arm will be activated to scan the wall area to be painted ; a software program will calculate the trajectory path of the paint spraying motion for the robotic-arm to carrying out the paint spraying action.~~

~~(8) The use of a collection hood covering over the paint spray nozzle to collect any paint debris and paint fallouts during the paint spraying process.~~

~~(9) The use of a pair of facade protection wheel (6 in Figure 1) on the mini-gondola to cushion any impact of the mini-gondola made on the facade of the wall to be painted.~~

~~(10) The use of an Industrial PC (personal computer) to control a controller located on the roof-top to monitor the paint level within the paint container to ensure that paint availability is maintained.~~

~~(11) The use of water weight for counter balancing on the motor-driven pulley system.~~

1. A spray painting system for spray painting external walls of building, the system comprising:

a gondola for hanging on a motor driven pulley system, wherein the gondola operationally traverses along a pair of rails travel along a linear distance of the rails for a painting process to be carried out;

a six-axis robotic arm, coupled with a 3D camera, and a spray nozzle on its end effector, the six-axis robotic arm is seated on the gondola for carrying out spray painting on the external walls;

wherein the 3D camera mounted on the robotic arm operationally scans a wall area to be painted; and

a software program adapted for receiving the scanned results from the 3D camera and calculating the trajectory path of the spray painting's motion for the robotic arm.

2. The system according to claim 1, further comprising a counter weight for counter balancing on the motor-driven pulley system.

3. The system according to claim 1, further comprising a collection hood covering over the paint spray nozzle to collect any paint debris and paint fallouts during the spray painting process.

4. The system according to claim 1, wherein the gondola further comprises a pair of facade projection wheel adapted for cushioning impact of the gondola made on the facade of the wall to be painted.

5. The system according to claim 1, further comprises an industrial PC (personal computer), the industrial PC is adapted for controlling the motor-driven pulley system to hoist and lower the gondola to locate the vertical location of the robotic arm.

6. The system according to claim 1, further comprises a controlling motor of the pulley system that hoists and lowers the gondola in parallel to the external wall of the building to be painted, wherein the controlling motor is located within the gondola.

7. The system according to claim 5, further comprising:

four vacuum suction cups mounted respectively on each linear actuator to secure the gondola to the wall when the robotic arm makes a 'stop' for the

painting process to be conducted; the suction cups are controlled by the industrial PC (personal computer) located within the gondola.

8. The system according to claim 5, wherein the industrial PC is adapted to control a controller located on a roof-top of the building to monitor a paint level within a paint container to ensure the paint availability is maintained.

9. The system according to claim 1, further comprising:

three ultrasonic distance sensors mounted on each linear actuator on the gondola to measure the distance between the gondola and the wall that is to be painted; wherein the distance measured is fed back to control the distance between the gondola and the wall to be painted.