

## **Winrobo—an automated window washing robot**

### **Official Final Posting Version 1.0**

#### **Basic problem description:**

Design, build, and demonstrate a robot which will wash a residential double-hung sash window autonomously, that is, without human intervention beyond placing the robot on the lowest window pane and turning it on, or under remote control of an operator “inside” the “building”. This device should be able to clean both the inside and the outside of a double-hung sash window, but this contest will be based on cleaning the outside of the window. A large scoring bonus will be given to those teams who are successful in completing any substantial part of this operation autonomously.

This device will be of help to many householders, but particularly to those with mobility problems which keep them confined to a wheel chair. Being able to clean the outside of the window automatically should provide a safety benefit to all homemakers, particularly those with older upper floor windows to clean.

The object of this contest will be to demonstrate a “proof of concept” design. Specifically, the robot must travel over the window as if cleaning it. The window surface will be marked with approximately 12 mm diameter circular dots made with “dry erase” ink which the robot will have to remove. The robot must carry with itself a quantity of water to simulate the cleaning solution necessary in the final device but will not use any water in the demonstrated cleaning operation.

For the purposes of testing in this contest the window in question will be a double-hung window. It will most closely approximate a Pella-manufactured window, their “ProLine” series, in size 2547. The window pane will be clear of obstacles such as mullions (which break the window pane into a number of smaller panes when used.) A simple-to-construct window of nearly the same construction dimensions is given in the drawings given as part of this contest definition, but equivalent-sized windows by any major manufacturer could be used for team testing as well as at the competition. A good robot will be able to accommodate to any of these windows or to similar-sized windows by any manufacturer.

#### **Requirements:**

- 1 Once placed on the window glass and turned on Winrobo must maintain itself on the specified vertical residential window and move around as necessary on the surface without assistance. Winrobo may touch or make use of the wood, vinyl, or aluminum surface surrounding the glass if desired, but may touch only those surfaces within 25 mm of any part of the (clear) window pane being cleaned. Winrobo may not touch the outside or the inside of the building wall or the trim area around the window (either inside or outside).
- 2 If operating autonomously, Winrobo must find the edges of the window on its own and complete its cleaning process—it may not be pre-programmed to only clean the one size window specified for this contest.
- 3 If operating under remote operator control, the following rules apply:
  - a The controller and the robot must be connected by an umbilical cord which carries only control signals. The control box may not include any batteries or auxiliary power. Radio control is not permitted.
  - b The umbilical cord must be connected to the robot through a commercially-

available 9 or 15 pin sub-D connector

c. The umbilical cord cannot be more than 2 mm in its thinnest dimension so that it can pass through a crack above or below a closed window.

d. The umbilical cord must be able to withstand repeated clampings between the moving and stationary parts of the window without damage.

3 Winrobo must be provided with a safety cord which can be closed into the window frame or otherwise secured in a non-marring way to the building wall, and which will prevent Winrobo from falling more than two feet below the elevation of the middle of the lower window pane in the event of a malfunction. If an umbilical cord is used it may NOT also be used as the safety cord.

4 While on the window Winrobo must clean the window by wiping off the dry erase ink used to simulate dirt on the window.

5 Winrobo must carry within itself 50 ml of water, which will simulate the cleaning fluid which would be used in the final design. This water must not leak out or be pumped out of the device during testing. It will not be used in actual cleaning.

6 Winrobo must /be capable of cleaning the entire window pane on which it is mounted. It may not leave some areas which it cannot clean (such as under attachment points on the window pane if, for example, immovable suction cups were used to hold Winrobo to the window).

7 Winrobo should be capable of moving from pane to pane on the window on its own or under operator control from inside the “building”. A major scoring bonus will be awarded for successfully completing the transition from lower to upper window pane.

8 Winrobo must be battery powered. The maximum battery voltage allowed is 24 Vdc maximum. The battery must be rechargeable. Winrobo must be capable of cleaning the outside of the test window without needing to be recharged.

9 Winrobo must have a safety system on it so that if the battery voltage drops below a “safe” level it will go into a “safe” mode where it stops cleaning and simply clings to the window pane while turning on a warning light. Team members must be able to describe this system to the judges as part of the qualification inspection.

10 When Winrobo is finished with a window it must turn off all cleaning operations, go the lower left-hand corner of the lower pane as viewed from the outside of the “building”, and turn on a signal light to indicate finished status.

11 The maximum allowable time for Winrobo to clean a window (both panes on the outside of the window) is 5 minutes.

13. Winrobo must be capable of being packed, fully assembled and ready to operate, inside a box with the inside dimensions of 600mm x 800mm x 300 mm high. The 300 mm dimension is the horizontal distance between the window pane and a

vertical plane tangent to the point of Winrobo which is farthest from the window when Winrobo is in the operating position.

12 Winrobo must not weigh more than [1 kg] when fully charged with fluids.

13 Winrobo may not damage the window or window frame in any way.

### **Contest operation**

1 At each contest one residential window will be provided. This may be a window built to the specifications of this contest, or may be a commercially available one. The exact type and size of the window is up to contest organizers, so long as the size of the visually clear panes fall within the range of 50 to 53 cm in width and height.

2 The judging team will mark off the inside of the test window with a regular grid of lines spaced approximately 105 mm apart and as nearly square as practical. Only integral numbers of rows and columns should be used. For the recommended windows a grid of 5 rows and 5

columns is suggested.

3 Immediately following check-in and sizing inspection all teams will have about one-half hour to prepare and test their devices. Test windows or window panes will not be provided by the organizers, and testing may not be done on the actual contest window. Teams should be prepared to test their devices as necessary during this time.

4 Once all teams have assembled and prepared their devices all teams will participate in a peer review session. During that time team members are expected to review all of the competing devices and to review them for any potential rules violations. If a team member suspects a device does not meet contest specifications he or she should report the problem to one of the contest judges. At the conclusion of the peer review session the judges will resolve any questions and conflicts. ***After the close of the peer review session no more questions will be accepted by the judging team from any team member about another team's device or its operation.***

5 During the peer review session the judging team may also conduct their qualification inspections to assure rules compliance.

6 After the peer review session teams must charge their devices with the water to simulate cleaning fluid and prepare for the contest. The charging must be done under observation by one of the judging team. Once charged any device may not leak fluid. If the judges find a device leaking prior to (or after) the team's testing period they may, at their discretion, give the team one warning and allow them to fix the leak. If the leak is not fixed or recurs then the team will be disqualified.

7 Following check in and inspection, teams will be assigned a testing order in an appropriate random manner.

8 Once the judging team has completed inspection and declared a device qualified the device may, at the Chief Judge's discretion, be placed in an impound area to await its testing turn. The team must place Winrobo in impound in a "ready-torun" configuration.

9 Before the judging team calls up a contesting team they will take a clean dry cloth or clean paper towel and carefully clean all of the outer surface of the window.

10 Once the window is cleaned the judging team will then take a "dry-erase" marker and place a dot about 12 mm in diameter on the outside of the window and within (but not necessarily centered within) each of the boxes marked out earlier on the inside of the window.

11 When a team is called to compete they must bring their charged and ready Winrobo to the testing arena where the window is placed.

12 Following a signal from the judging team, each team will have a maximum of 5 minutes to place Winrobo in the lower left-hand corner (as viewed from the outside) of the lower window, turn it on, and leave it or control it to complete the cleaning of the outside of the window. (Time spent in setting up or placing the robot on the window is included in the time limitation.)

13 The "test time" will stop when Winrobo determines that it has completed cleaning the window, parks itself in the lower left hand corner of the window as seen from the outside, and turns on its "done" light, or when the 5 minute time limit is reached.

14 At the judges discretion, and at the end of the contest for qualified devices the judges may allow disqualified teams to demonstrate their devices to other contestants and observers, but scores for these devices will not be kept or reported as they are not part of the contending group.

## Scoring

The scoring factors will be:

- a. Percent of window area cleaned. This will be calculated based on the fraction (percent) of the number of dry erase dots completely removed from the outside of the window.
- b. Time required to clean the window, measured in seconds
- c. Bonus for operating autonomously at all times
- d. Bonus for parking device, turning on light when done within time limit
- e. Bonus points for climbing onto upper window
- f. Any touching penalties, including DQ
- g. Penalties for spilling water during testing, including DQ

The actual scoring equation will be:

$$\begin{aligned} \text{Score} &= 600 ((N-n)/N) \\ &+ 400 ((300-t)/300) \\ &+ 500 B \text{ ( } B= 0 \text{ or } 1 \text{ if Auto.)} \\ &+ 200 P \text{ (} P=0 \text{ or } 1 \text{ if parked)} \\ &+ 200 C \text{ (} C=0 \text{ or } 1\text{)} \\ &-50 H \text{ (} H \leq 2 \text{ or DQ)} \\ &-100 (s, \leq 1) \end{aligned}$$

Definitions of variables in the equation:

t Time required to complete the operation, in integer seconds ( $t \leq 300$  or DQ) N Number of dots on both windows to START n Number of dots LEFT at end of run B Bonus for autonomous operation, binary value, B=1 if true P Team parks device and turns on signal at end of run, binary, P=1 if done, otherwise 0 C Bonus for climbing onto upper window, C=1 if true, 0 otherwise (Binary) H Team touches device during run.  $0 \leq H \leq 2$  or DQ s Number of water spills,  $\leq 2$  or DQ

Maximum score wins.

In the case of a tie, the Winrobo completing the task in the shortest period of time will be declared the winner.

CJH 05/29/2007