Winrobo

The automated window-washing robot

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Problem Statement

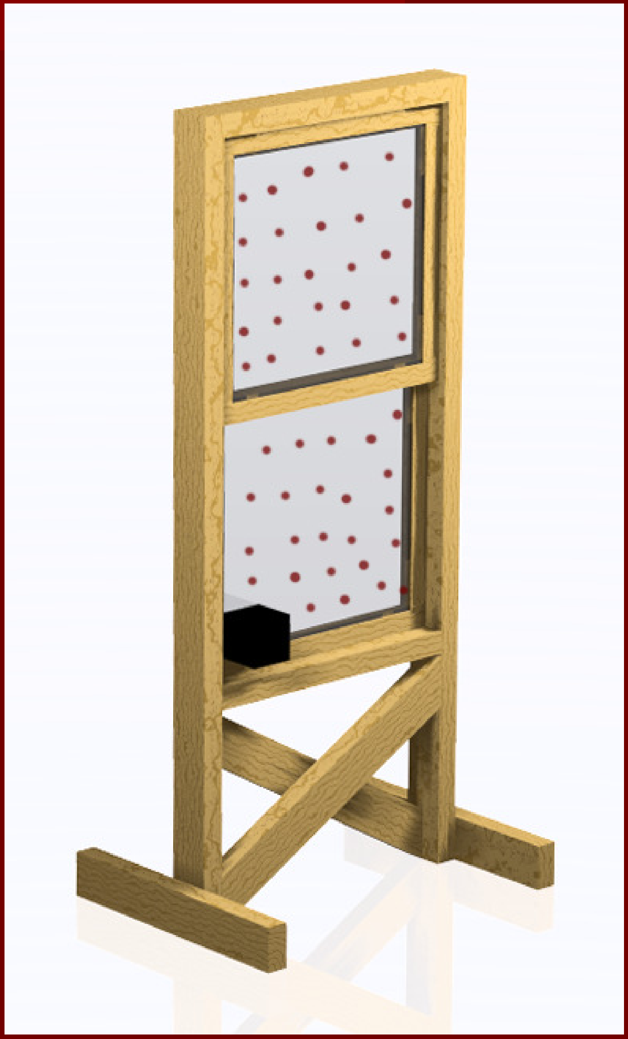
- Clean difficult to access windows
- Automate window washing
- Helping people with disabilities to clean hard to reach windows

Customer

- ASME 2008 Student Design Competition
- Home owners, commercial cleaners, disabled people

Device Function

- Device is placed in lower left-hand corner of window
- Cleaning operation starts with the simple push of a button
- Device autonomously removes dry erase marker dots on one side of the window (upper and lower panes)



Quantitative Requirements

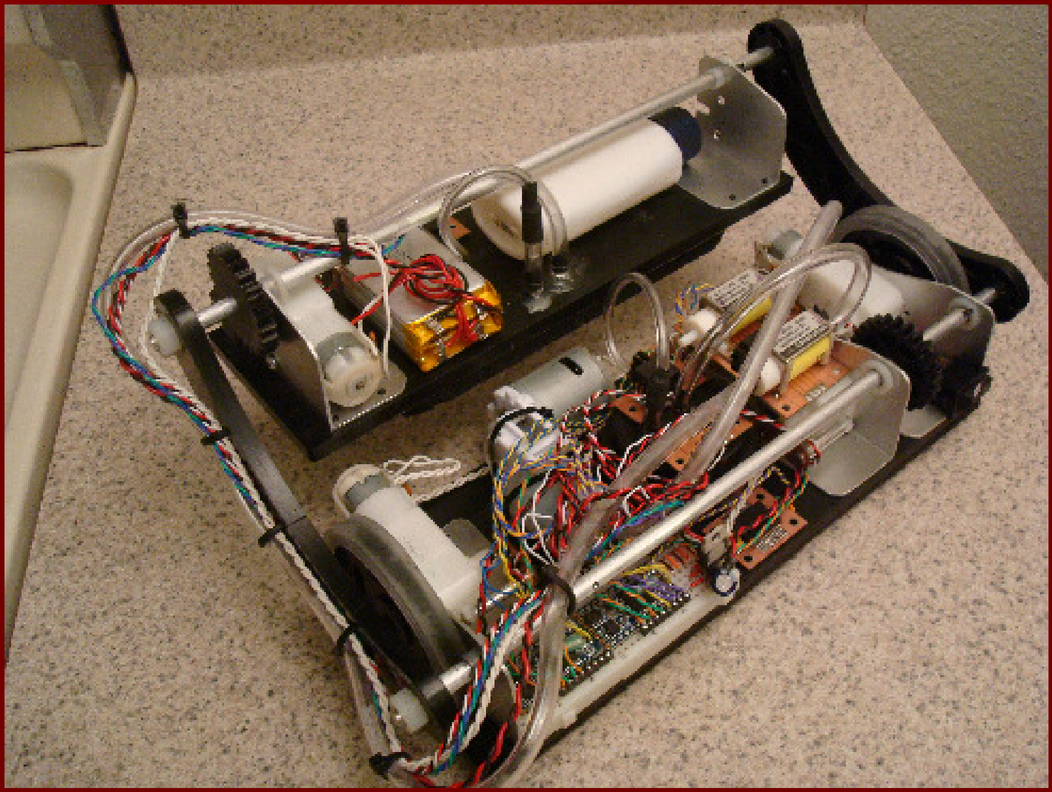
- Must remove 90% of dry erase dots, on one side only
- Must finish in < 5 minutes, including setup time
- Must weigh < 1 kg when charged with cleaning fluid
- Must carry 50 ml of cleaning fluid (water)
- Must be battery powered, 24 V battery max
- Must clean 2 window sides per charge
- Must be < 600 x 800 x 300 mm when ready to operate
- Must only touch the glass and surfaces within 25 mm of the glass

Qualitative Requirements

- Must wash window autonomously
- Must be able to survive fall from window
- Must have a simple user interface
- Must clean various sizes of windows
- Must have a safety cord preventing it from falling 2 feet below the middle of the lower window pane
- Must have a 'safety procedure' that causes the system to remain on window when voltage drops below safe levels
- Must return to starting point when finished cleaning
- Must not damage window while cleaning

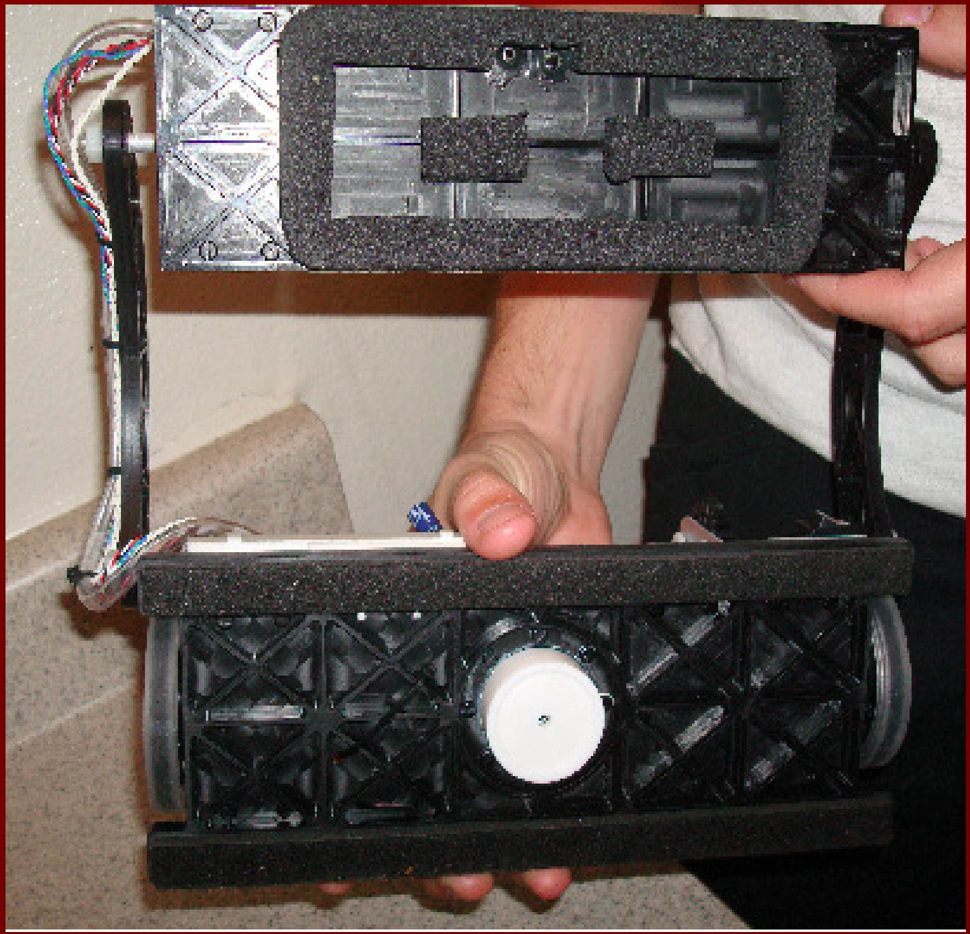
Final Solution - Cruiser

- Differential drive robot
- Autonomous operation
- Closed-loop motor control



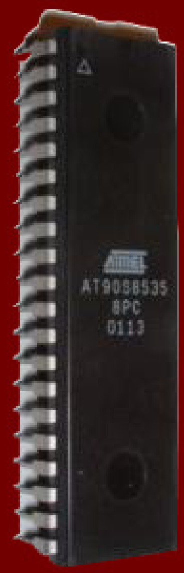
Final Solution - Cruiser

- Sliding teflon vacuum seal
- 2-axis window transfer system



Hardware

- Electronics
  - Atmel AT90S8535 microcontroller
  - GM-3 DC motors
  - MC33887VW amplifier
  - MLX90316 magnetic encoders
  - Lithium-ion prototype 3.7V batteries
  - Consumer vacuum pump
- Sensors
  - MPXV7002 pressure sensors
  - ADXL202E accelerometer
  - Pneutronics three-way solenoids



Fabrication

- Body
  - Delrin plastic
  - CNC fabrication
- Other
  - Aluminum rods and brackets
  - Delrin gears
  - Small plastic water bottle for cleaning fluid

Drive system

- Closed-loop PID control on 4 axis
- Low cost control system
- Lightweight power supplies
  - 3.7v battery weighs 22g each

Pneumatics

- Low cost pneumatic pump and valves
- Closed-loop vacuum control
- Sliding seal
- Collapsible piston seal

ASME Competition

- Device met qualifying requirements
- Placed second

Test Results

Durable		Fail
Simple User Interface		Pass
Clean Various Size Window		Pass
Remove 90% Dots		Pending
Finish < 5 min		Pending
Carry 50ml Water	50ml	Pass
Safety Cord		Pass
Weight < 1kg	998g	Pass
< 24V Battery Supply	11.8V	Pass
Clean 2 Window Sides		Pending
Size Requirements		
Height < 600mm	206mm	Pass
Width < 800mm	289mm	Pass
Thickness < 300mm	105mm	Pass
Only Touch Glass Surface		Pass

Unique Challenges

- Teflon seal durability
- 5 week development time
- Backlash in gear system
- Electronic integration
- Wire management
- Electrical noise (accelerometer)
- PID update frequency

Final Budget

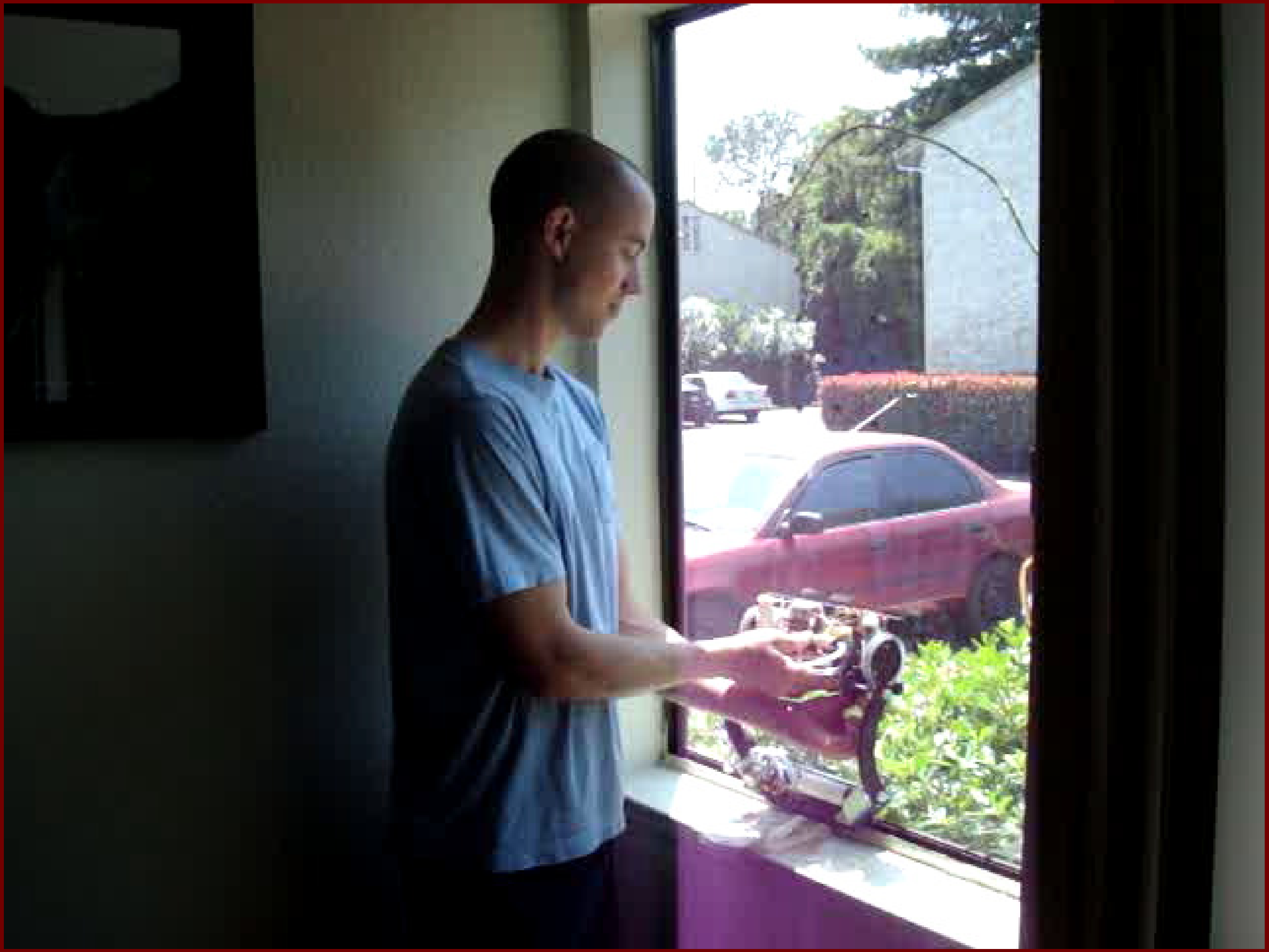
- Labor:
  - $35.04 /hr
  - 40% overhead
- Final Costs
  - $188.82 per person ($100 budgeted)
  - Total w/ Labor:
    - $49,811.27

Item	Cost	
Motors	$	33.53
Encoders	$	54.57
Processors	$	150.00
Pressure Sensors	$	30.00
Accelerometer	$	5.00
Batteries	$	96.00
Charger And Adapter	$	26.00
Electrical Components	$	13.00
Pumps	$	20.00
Polymers	$	49.00
Foam/Felt, Tubing, Teflon	$	116.07
Aluminum Plate/Shaft	$	70.49
Wheels	$	21.83
O-rings, Roll Pins	$	23.00
Hardware, Grease	$	31.78
Mill Bit	$	10.00
Sand Paper	$	5.00
Supplies Total	**$**	**755.27**
Labor	$	35,040.00
Overhead	$	14,016.00
Grand Total	**$**	**49,811.27**

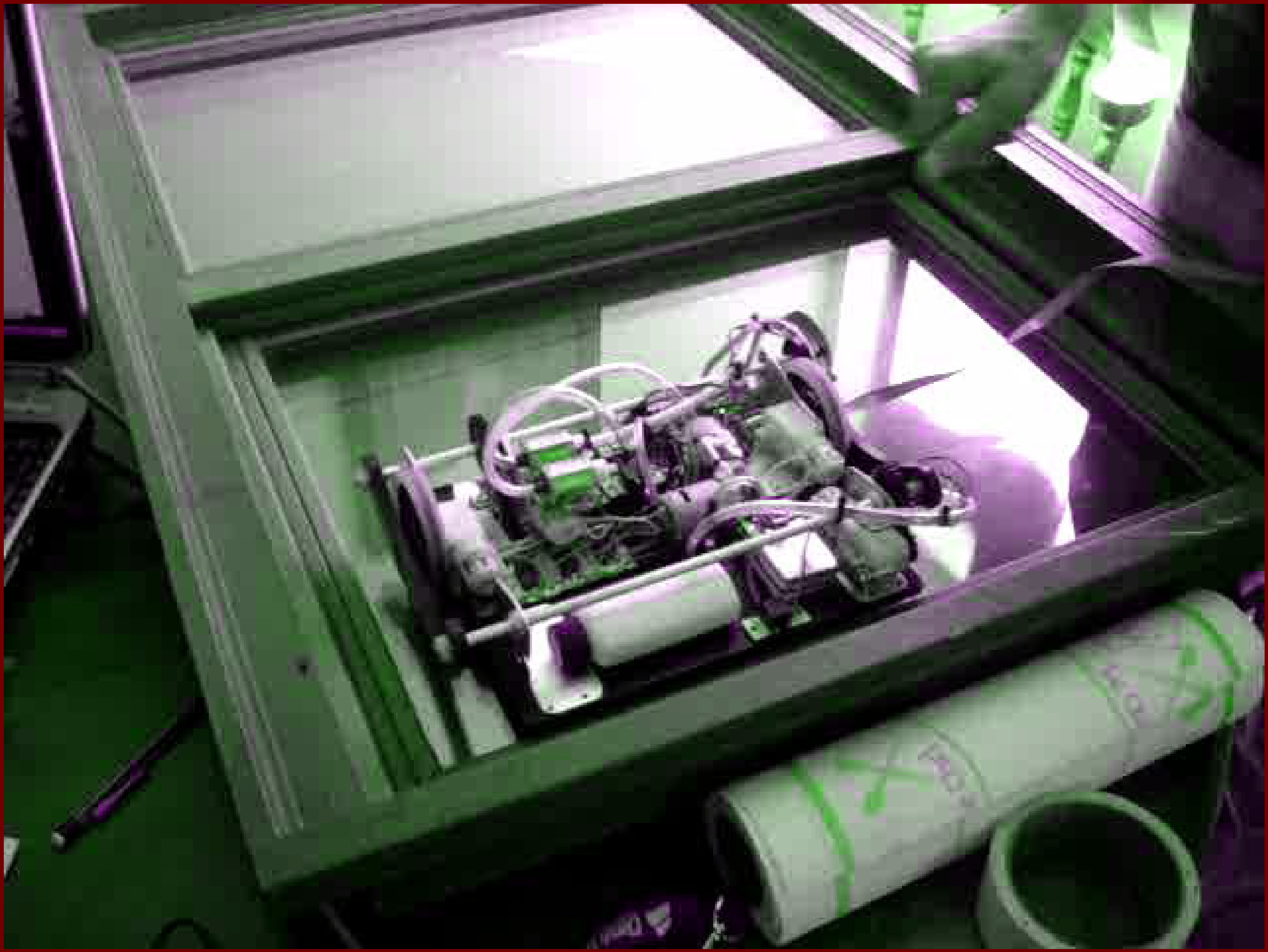
Production Cost Estimate

Component	Quantity	Cost	Total
Motor	3	$3.00	$9.00
Encoder	3	$2.00	$6.00
Amplifier	4	$5.00	$20.00
Pump	1	$5.00	$5.00
Processor	2	$2.00	$4.00
Batteries	3	$5.00	$15.00
Hardware	1	$5.00	$5.00
Plastics	1	$5.00	$5.00
TOTAL			**$69.00**

Demo Video



Demo Video



Conclusion

- Final Solution
  - Successfully developed proof of concept
  - Demonstrated key technologies
  - Performed at competition
  - Potential commercial product pending further development

Acknowledgements

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