OBSTACLE AVOIDANCE WITH A SEGWAY RMP

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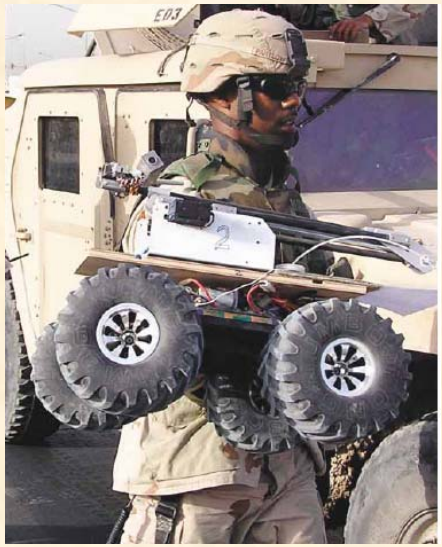
AGENDA

- Background
- Segway selection
- Movement characteristics
- Communication
- Obstacle Avoidance Algorithm
- Performance
- Future Work
- Conclusions

BACKGROUND



- Increased use of robotic vehicles in Army operations
- Interest in creating a “mule” vehicle to reduce infantry load

Photo source: Hasenauer, Heike, “Faster Equipping of U.S. Forces,” *Soldiers Magazine*, Vol. 59, No. 10, October 2004, pp. 20-23

SEGWAY SELECTION

- Human Transporter (HT) vehicle
- Inverted pendulum
- Internal balancing capability
- Maneuverability

Photo source: Segway website, www.segway.com, Accessed 12 October 2004

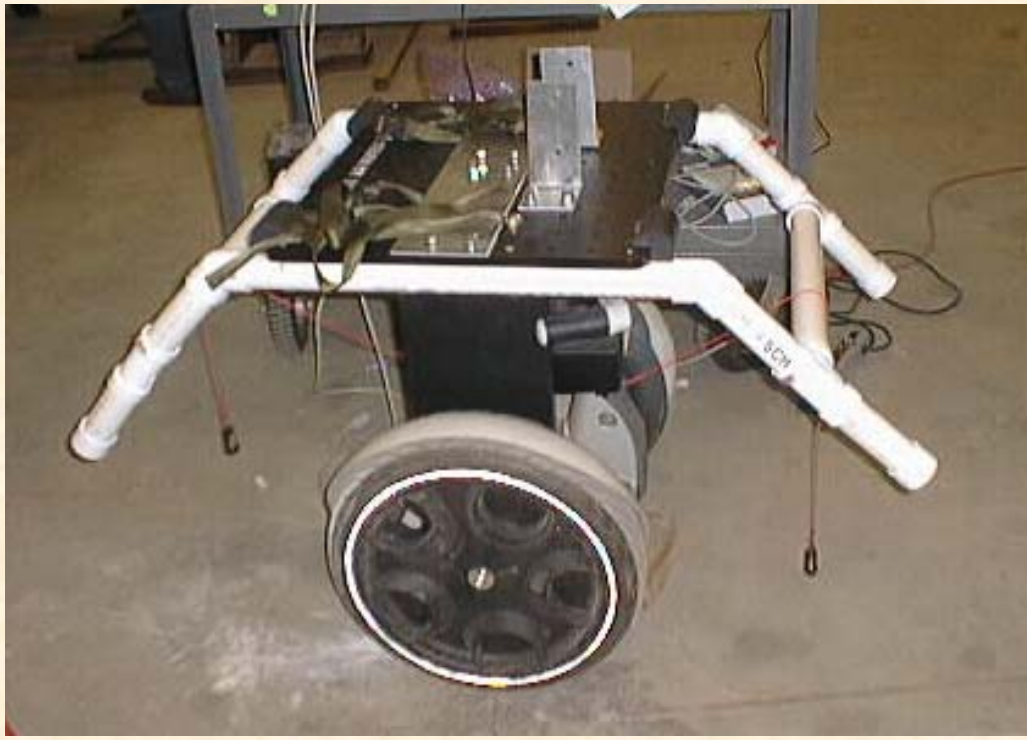
SEGWAY SELECTION

- Robotic Mobility Platform (RMP)
- Modified HT
- Same movement
- Command inputs different
- 45 kg (100 lb) load-carrying capacity on platform

Photo source: *Segway Robotic Mobility Platform (RMP) User Instructions*, Version 1.3, Segway LLC, 2004.

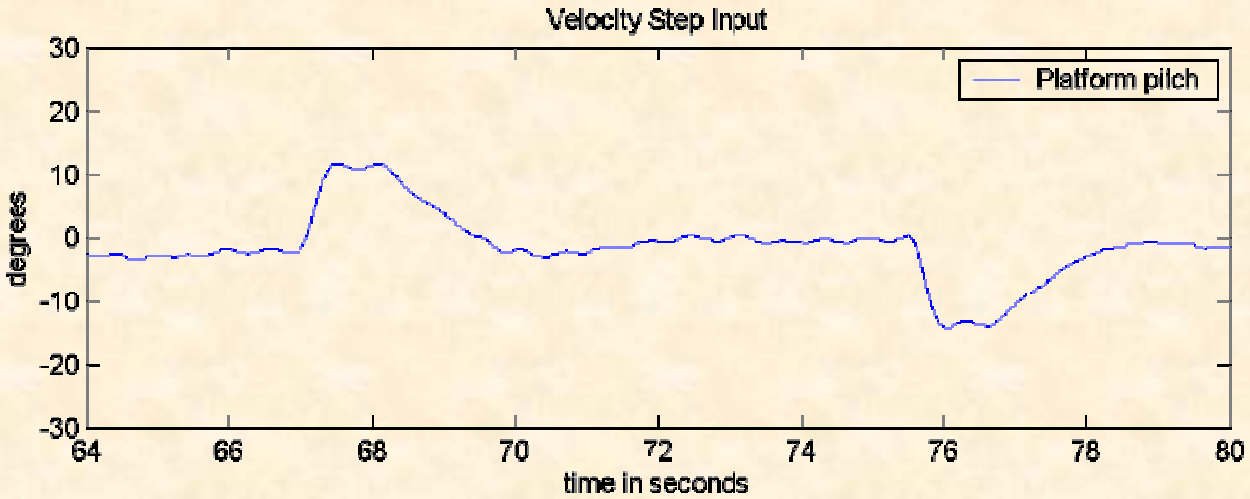
MOVEMENT CHARACTERISTICS

- “Chases” CG
- Start / stop requirements
- Small footprint
- Zero turning radius
- Safety
  - E-stop (quick disconnects)
  - Legs



MOVEMENT CHARACTERISTICS

- Velocity step command response – 1.77 m/s (4 mph)
- Acceleration set to one half of maximum
- Constant small amplitude oscillations



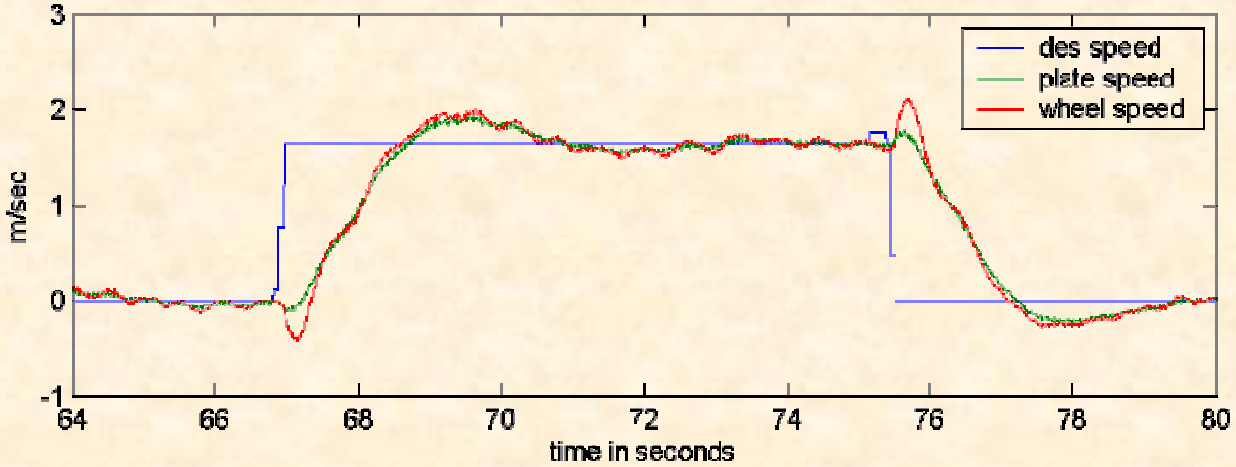


Figure source: *Segway Robotic Mobility Platform (RMP) User Instructions*, Version 1.3, Segway LLC, 2004.

COMMUNICATION

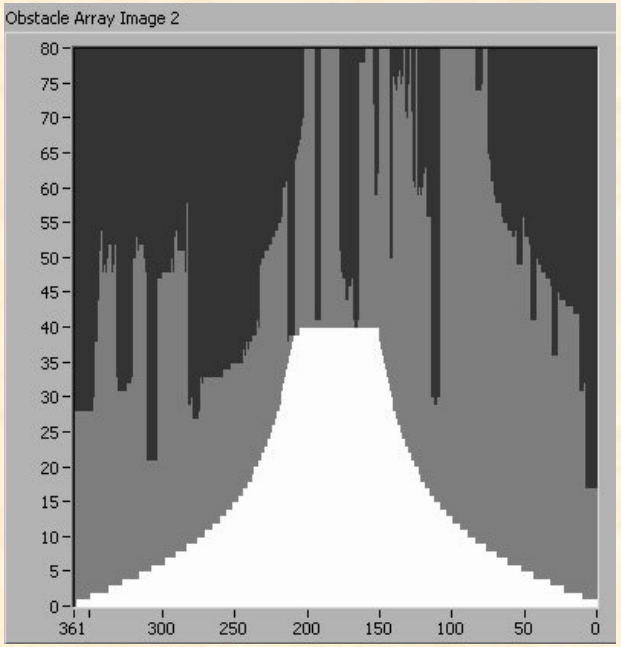
- Interface with RMP through serial ports
- Controller Area Network (CAN) PCMCIA cards in laptop
- Command software resident on laptop
- USB joystick for direct movement control
- Sick laser connected to serial port on laptop

OBSTACLE AVOIDANCE ALGORITHM

- LabVIEW used as integrating software
  - Send initialization command to laser
  - Receive laser data
  - Path seeking algorithm
  - Movement command sent to RMP
- Obstacle array

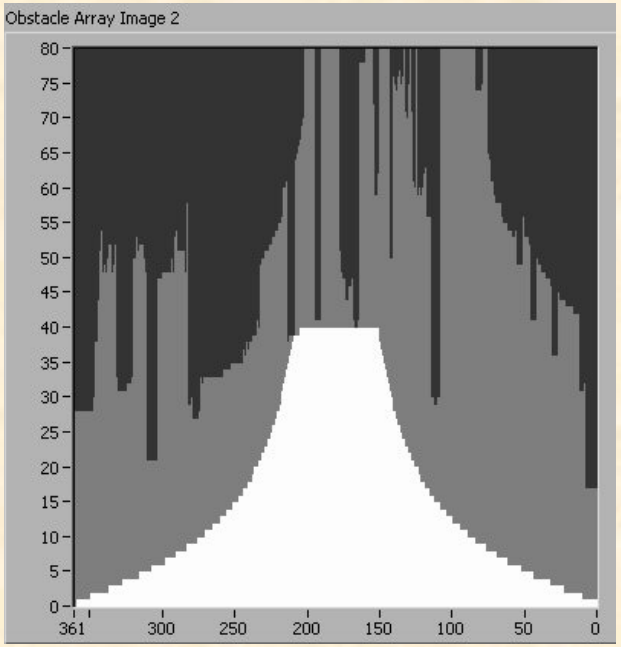
OBSTACLE ARRAY

- Laser data received as radial distance and direction for each of 362 beams (180°)
- Binary matrix created from laser data
  - Open path: 1
  - Blocked path: 0
- Converted to graphical form
  - Black: obstacles
  - White & gray: clear paths

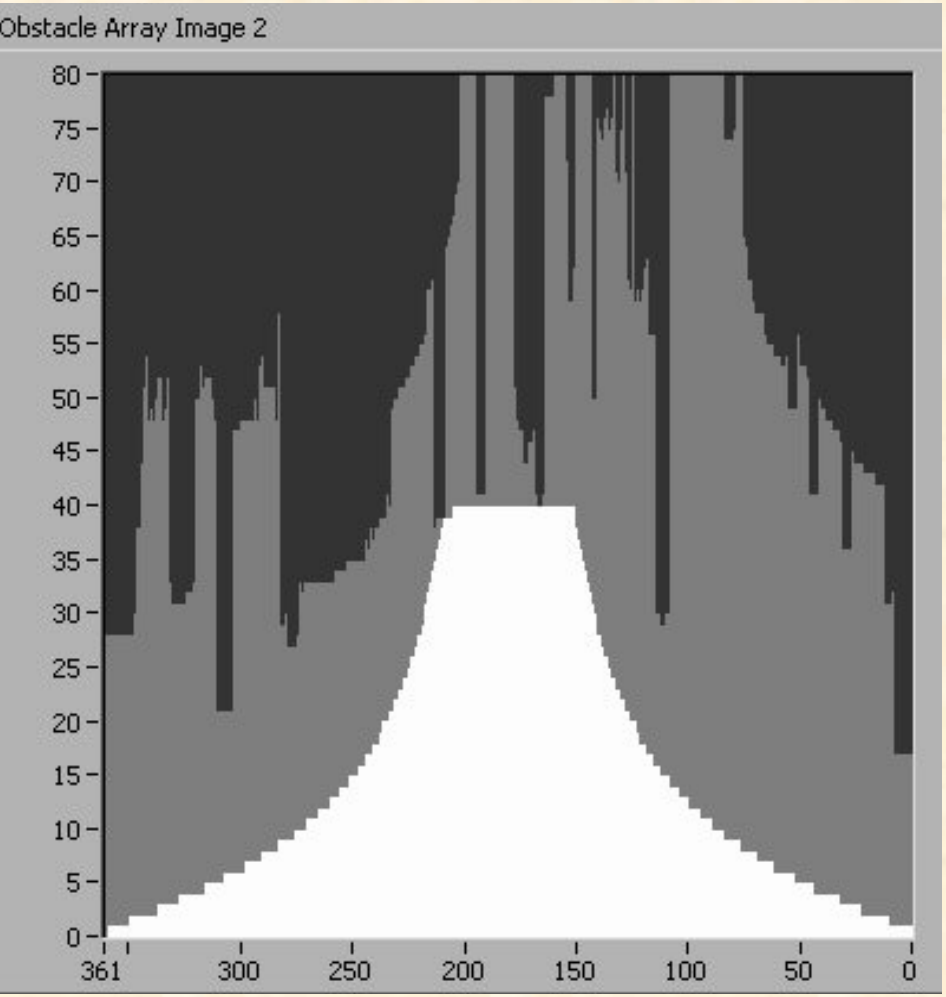


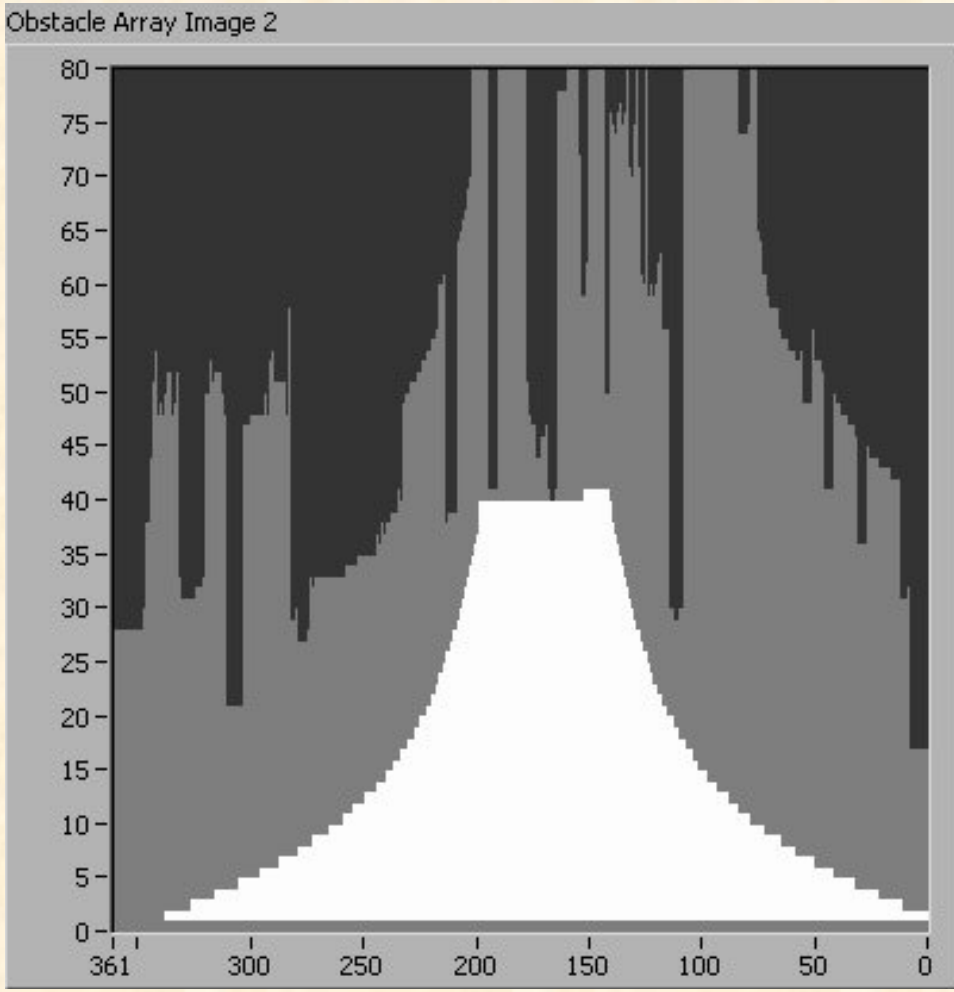
OBSTACLE AVOIDANCE ALGORITHM

- Searches along each beam index for longest open path of appropriate width
- Obstacle found:
  - Totals open area for that path
  - Compares all paths
  - Smaller for off-center beams
- Tends to favor center paths



OBSTACLE ARRAY





PERFORMANCE (INDOORS)

PERFORMANCE (OUTDOORS)

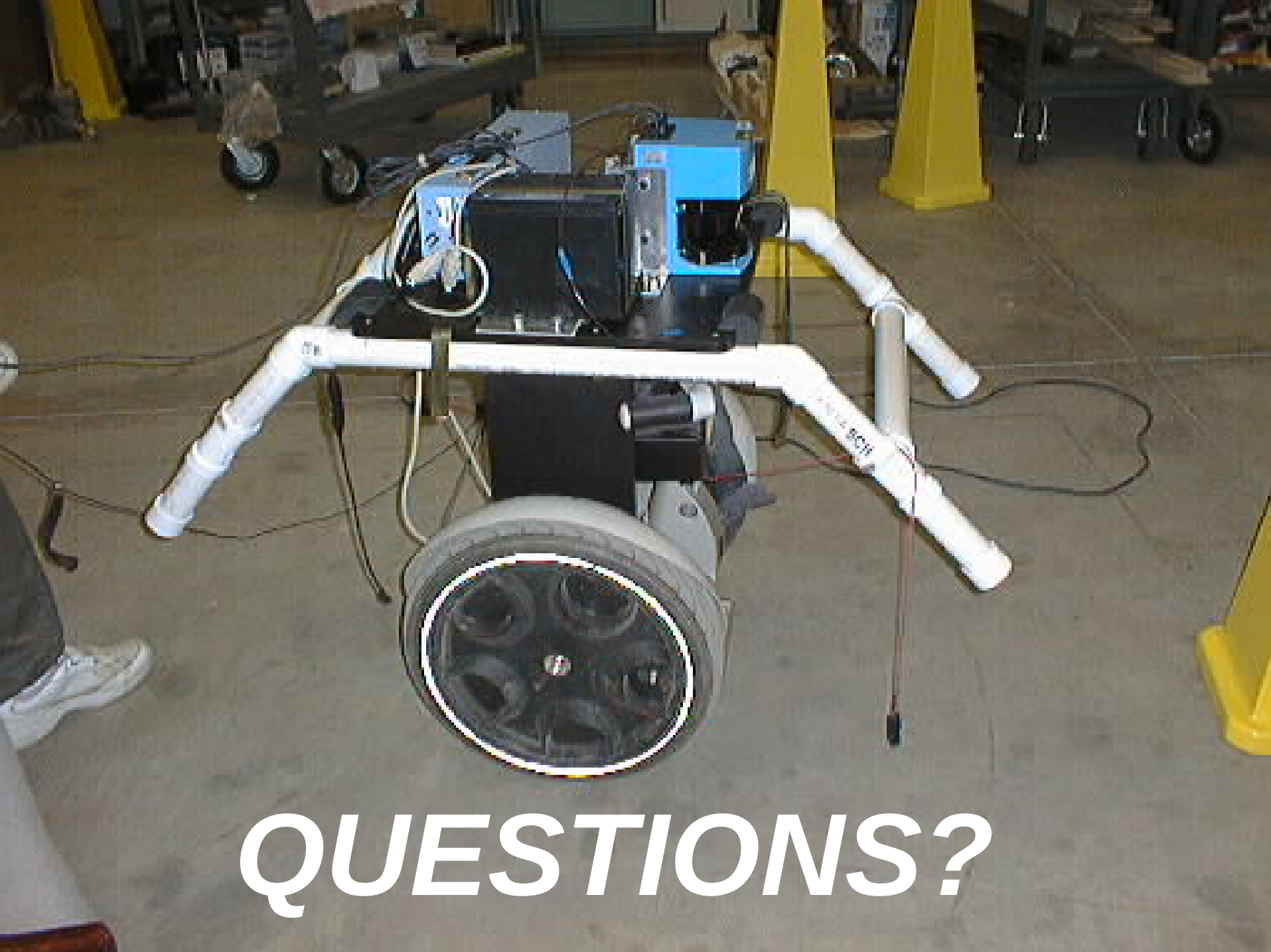
- Limitations evident
  - Rough terrain
  - Sharp bumps greater than 100 mm
  - Loss of traction
  - Tipping
- Performed well on rolling grassy terrain
- Obstacle avoidance excellent within sight of sensor

FUTURE WORK

- Following capability
  - Radio link between master and mule
  - GPS input to allow recovery of path after obstacle avoidance
- More detailed terrain data
  - Avoidance of drop-offs and other large obstacles

CONCLUSION

- RMP shows promise as load-bearing vehicle
  - Terrain limitations must be overcome
  - Automatic shutoff limitations
  - Two-wheeled geometry allows excellent maneuverability in tight spaces
- Obstacle avoidance algorithm allowed constant update of path choice


QUESTIONS?