Introducing a robotic wheelchair to computer vision

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Introduction
There are 5.5 million wheelchair users reported in 2014 in US where 9-15% are electric power wheelchair (EPW) users [1-2]. About 65-80% of wheelchair related accidents are due to tips and falls [3] which translates to hospitalization costs of $37,500 to $112,500 per person [4]. The Mobility Enhancement Robotic Wheelchair (MEBot) was developed to mitigate tips and falls by adjusting its seat within safety boundaries. Also, a curb negotiating application allows MEBot to ascend/descend a curb up to a height of 8 inches for accessibility when curb-ramps are not available.

METHODS
Phase 1: MEBot was compared to commercial EPWs in terms of wheelchair stability (seat angle changes) and task completion time. Ten participants drove their own EPW and MEBot for five trials each through driving tasks that replicated outdoor environments.

RESULTS
Phase 1: Self-leveling Time
The average time to level the seat at each waypoint of the compound slope and ±10° slope for each participant and average leveling time for all trials. MEBot self-leveling time (8.1 ± 2.6 seconds) was higher than the average walk time (2 seconds) in the up/down 10° slope. The time taken for MEBot to settle over the compound yielded a time average and a standard deviation of 7.8 ± 3.0 seconds.

Phase 1: Curb Negotiation Time
Results showed that participants required average completion time of 65.7.0 ± 19.5 seconds and 30.3 ± 9.1 seconds to ascend and descend curbs, respectively at different heights.

DISCUSSION
Phase 1: The time it took for MEBot to return below the threshold (±2.5°) of seat levelness was longer than the time required to complete each obstacle at average walking speed. The delayed responses in the self-leveling caused MEBot to overcorrect after driving over each obstacle resulting in an oscillation of the seat angle.

Furthermore, challenges with the pneumatics system included the non-linear response of the air valves and variability of air consumption that was affected by the participant’s mass, weight distribution, air tank volume, and air tank temperature.

Phase 2: Introduction to Computer Vision
Learning form Phase 1, MEBot capabilities can be improved by characterizing the terrain/obstacles and adjust its seat ahead of time.

MEBot can be programmed where it can provide autonomy to the user by providing helpful decision to prevent accidents or if they would negotiate an obstacle.

How does it work?
As you drive along with MEBot equipped with sensors to detect flat surfaces, curbs and, other obstacles [5]. MEBot can be programmed to negotiate this in real-time so that it prevents tips and falls. If the user desire to negotiate a curb (for better accessibility) or uneven terrains (safety), then MEBot will start the process earlier to make the transition smoother.