Urban Robotics Foundation

Blindspot — brief discussion related to PMR awareness (ISO 4448)

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For a human operated vehicle, a **blind spot** is an area around the vehicle that cannot be directly seen by the driver while at the controls. Analogously, for a teleoperated PMR[1] a blind spot would be any area that cannot be directly seen by the teleoperator, through the sensors on the PMR. For a PMR under ADS control (fully automated at the time of reckoning), a blind spot would be an area that cannot be directly sensed by the sensors that are feeding information to the ADS, and cannot be accurately inferred from recent sensor history.

Conceptually, these are similar matters but how they are mitigated differs. In this brief, we are concerned about PMRs that may be variously teleoperated, fully automated, or (most likely) in a state switchable from one to the other. Hence, ISO DTS[2] 4448 does not consider how a PMR manages blind spot(s) or computes decisions about the events in a blind spot, rather it specifies a maximum permissible blind spot to ensure full surround awareness needed in the context of its task and navigation to access that task.

We must be especially diligent about blind spot mitigation for devices that are moving among bystanders, some of who may be vulnerable road users, small children, animals, vandals, or automobiles that may be crossing the same crosswalks that the PMR is using.

In order to consider PMR blind spots in context, we first assert several things about what a PMR must be *capable* of being aware of regardless of the style of its operational software.

Context: What should a PMR be aware of?

We established earlier that a PMR might use any type, number or placement of sensors — ISO 4448 does not specify hardware, but only that the hardware employed provide the capabilities defined in the standard. We also established that a PMR might utilize any level of automation from none (pure teleoperation) to full automation (human oversight only) — ISO 4448 does not specify software, but only the software required to calculate what the PMR is required to be aware of.

What ISO 4448 does specify is the dimensions of the surrounding area (currently elliptical) in which a PMR must command full awareness so as to make *safe* and *intelligent* path planning decisions.

- *Safe* refers to the safety of bystanders within a proximity defined by the comparative speed of the bystander and the robots. For example, proximity in case of a robot-bicycle interaction is a greater distance than that for a robot pedestrian interaction.

- *Intelligent* implies that the behaviour of a robot conforms to a logically and socially appropriate pattern of navigation and space-sharing. For example, a robot shall not stand within a curb cut blocking a wheelchair that is approaching to mount that curb.

Note that the above definition of safety is very narrow and the exhaustive safety specification within DTS 4448 is considerably more involved, but here we are concerned with the immediate navigation aspects as a PMR moves among bystanders. As well, the definition of intelligence is also much broader, but here constrained to what a bystander would judge as expected from a well-behaved, respectful device — in other words the robot moves sensibly and acceptably according to our social expectations.

[1] Public-area mobile robot
[2] Draft Technical Standard

To discuss this, we consider one of the most critical urban navigation spaces for a PMR: the crosswalk at a traffic intersection of a typical urban arterial. 4448 asserts that a PMR must not enter such a crosswalk unless it can be nearly certain that it will be able to clear that crosswalk. Of course, knowing that this is a dynamic environment, neither the PMR nor its teleoperator can be 100% sure that initial conditions will hold (for example a motor vehicle might intrude on the crosswalk after the PMR commenced crossing – see Figure 1). Briefly, an urban arterial crosswalk of 18m (5 x 3.5m lane widths), would take a PMR travelling at 5 kph 13 seconds to cross — in perfect circumstances.

Figure 1: This PMR entered the crosswalk before the right-turn-on-red car entered to block its path. While ISO 4448 stipulates that a PMR shall travel within a marked crosswalk (when it is so marked), and also stipulates that a PMR not reverse or U-turn during a road-crossing maneuver (note in the bottom left corner that another vehicle is turning right behind the PMR. In this circumstance, the PMR subsequently turned out into the roadway to cross in front of the vehicle, breaking the first rule, which, in the circumstance, was the least hazardous rule to ignore, and coincidentally furthered the PMR's navigational goal of crossing the street. All of this may seem obvious to a teleoperator accustomed to crossing such streets. However, ISO 4448 is intended to set rules, priorities and procedures that will be included in the decision software for these machines.

This provides a trivial conclusion if we are operating at purely pedestrian speeds in typical circumstances. But some PMRs operate in bikeways and others on roadways — and there will be many atypical circumstances. Hence, we are required to work out tables indicating sensory and decision distances for forward-navigation awareness in each such operating environment. Those sensory capabilities and must take variation into consideration. For example, if the sensors and software/teleoperator cannot satisfy specified distance requirements because of weather conditions, how should that fleet operator proceed?

The tables and illustrations for this have been updated since our January members meeting, and are available in ISO 4448-16 paragraph 4.2.1.4 in member resources. Email Leestj@urbanroboticsfoundation.org if any issues.

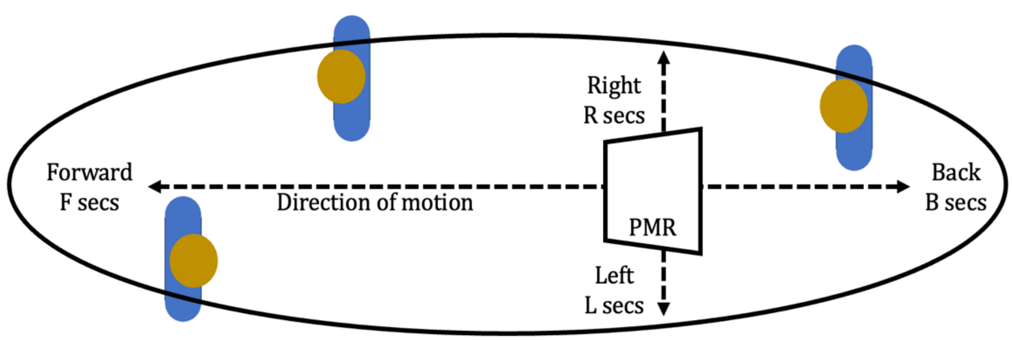

Figure 2: The "surround awareness ellipsoid" within which a PMR is able to detect and determine the presence of objects to interpret, navigate around, protect itself from, or record in regard to intersection safety or vandalism. The dimensions of this ellipsoid (it has height, too!) depends on the speed and environmental circumstances in which a PMR is operating.

So, we've determined that PMR's must see a certain "decision time-distance" in front of them as measured according to intended speed and conditions. However, 4448 also specifies that a PMR must have 360° sensory and decision awareness. Reasons for this include anticipating a requirement for a trajectory change to the right or left, anticipating what is behind with respect to intention signaling, U-turns, and (sadly) vandalism. Hence 4448 specifies that a PMR must maintain and manage a "surround awareness ellipsoid" that conforms in distance (time) capability according to operating speed – see Figure 2.

Considerations for a robot's blind spots

Above, the *surround awareness ellipsoid* provides 360° awareness for various distances depending on various circumstances (Figure 2). However, the issue of blind spots arose at our last meeting, and numerous examples including a cat or squirrel being struck by the wheels or feet of a PMR or the matter of becoming entangled in debris that the sensor systems could no longer see once entangled, so that even a teleoperator might not fully understand the circumstances. To resolve such cases would require that even the pavement beneath a PMR could not be in a blind spot.

But of far greater concern is a small child rushing up to touch a robot (which happens quite frequently, if you trust YouTube), or for a vandal that might understand how to take advantage of blind spots. We sought to define a permissible blind spot that was limited to a small number of centimeters outside the perimeter of the PMR footprint. Such a permitted maximum blind spot would be an area of ***C*** centimeters beyond the footprint of the PMR so that no human regardless of how tiny or stealthy could hide there. ***C*** will likely be as little as 10 or 15 cm. This will be determined at a subsequent URF member's meeting.

Summary

When considering matters of path planning and safety responsiveness — whether software or teleoperator mediated — the requirement for a minimum surround awareness ellipsoid seems obvious. It may also appear obvious that such a minimum ellipsoid must have no field-of-view blind spots. However, the eradication of a blind spot within the PMR footprint, or very close thereby, may be difficult. Not only might this require additional sensors, but keeping those sensors clean could add an onerous expense both in manufacture and maintenance for possibly very little safety advantage, unless that advantage is measured in insurance premiums.

As this technology improves it will likely be possible to eradicate such blind spots with processing as a PMR moves along a pathway since it would be impossible for any intrusion into the narrow domain around the footprint of a PMR without first passing through (and being observed) the surround awareness ellipsoid. The remaining flaw in this logic is the fate of the object, animal, or person that intruded. This will be considered in a subsequent draft of this part of ISO 4448.

Meanwhile, it is left for the 4448 DTS to propose, and for the published TS to assert, a reasonable maximum blind spot from a stationary perspective, engineers to devise ways to accomplish that, and for certifiers to provide suitable tests.

This draft discussion will be expanded to encompass micro planning, meso planning, and macro planning, as three aspects of path planning that impact the surround awareness ellipsoid. – Bern Grush