Timo Malm*, Taru Hakanen, Josepha Berger and Sami Karadeniz

Uncertain information related to situational awareness of mixed fleet and AMR - Safety perspective

Abstract: Situational awareness is a key to enable safe mixed fleet or AMR (automated mobile robot) and manual operations in situations where uncertain information is the puzzling factor. Uncertain information may be used sometimes, when reliable information is not available, for example due to limited Performance Level (PL), disturbances, environment, or poor visibility. The question here is, can uncertain information be applied for safety purposes. Safety must not be jeopardized. Case specific risk assessment is needed to ensure safety. Safety measures based on uncertain information may be acceptable if they are limited to specific conditions, such as a defined time frame, reduced speed, controlled distance, adequate visibility, or a particular mode of operation.

Keywords: uncertainty, autonomous mobile machine, AGV, AMR, mixed fleet

***Corresponding Author: Timo Malm:** VTT, Finland,
E-mail: timo.malm@vtt.fi

Taru Hakanen: VTT, Finland,
E-mail: taru.hakanen@vtt.fi

Josepha Berger: VTT, Germany,
E-mail: josepha.berger@vtt.fi

1 Background

New Machine regulation (EU) 2023/1230 [1] describes autonomous mobile machinery and related basic requirements. According to the regulation the collision avoidance system is based on either peripheral protection system or on-board devices intended to detect human or any other obstacle in its vicinity to avoid collisions. The peripheral protection system is typically related to fleet management, which is capable to control access into parts of the system to avoid collisions. On-board protection system forms a situational awareness area beside the mobile machine to maintain safe distance to obstacles. Situational awareness is defined as “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future” [2]. In MixedFleet project the original definition remains the same, but we apply the concept on mixed fleets including both M2H (Machine-to-Human) and M2M (Machine-to-Machine) perspectives [3]. Situational awareness refers typically in on-board systems to the mobile machine and in peripheral protection systems to fleet management. Situational awareness can be also dynamic so that it depends for example, the phase of the process or the traffic density. Situational awareness can be related also to persons (M2H), which means that a person receives information and forms his own situational awareness notion. All these different situational awarenesses are related to safety.

Situational awareness can be based on e.g. reliable information gathered from sensors and safety PLCs having adequate (safety) Performance Level (PL) and applied according to device manual, or e.g. uncertain information based on e.g. information from sensors having inadequate PL, inadequate physical capability (e.g. detection range), information is not up to date, or the information contains errors.

2 Aims and methodology

The aim or question here is, how uncertain information can be applied for safety purposes.

The method is here first to get information from interviews, group discussions, standards, and literature. Then the gathered ideas related to uncertainty have been tested with researchers and with designers . Finally, the conclusions are made from the gathered material.

3 Results

Uncertain information is applied sometimes in the industry. Uncertainty is more common in outdoor environment, where rain, fog or snow may reduce visibility remarkably. The focus is here on indoor applications, but some examples are related to outdoors use.

Situational awareness refers here to mixed fleets, including AMRs, and manual machines, which all are

capable to model their environment to avoid collisions. This is related to detection of objects, adequate separation distance, and concluding results with adequate safety logic.

Common reason to uncertain information is inadequate Performance Level (PL). PL means discrete level used to specify the ability of the safety-related parts of the control system to perform a safety function under foreseeable conditions. PL can be associated to probability of failed safety function [4]. Typically, integrators of the system try to choose equipment to the system so that they fulfill the PL requirements.

The origin of uncertain information related to indoor applications is often poor sensor perception due to e.g. high speed, object surface properties, misalignment of sensor (temporary or permanent), disturbance caused by other objects, object dimensions in specific height (e.g. forklift truck), lying person below detection field, inclined ground surface, a hole in the floor, object approaching behind a corner, or other object. Other origins for uncertain information coming outside of the machine are disturbed communication, old terrain map or wrong position information. Uncertain information can also be related to the situational awareness of a person. The person does not have correct information and makes a hazardous decision due to misinterpretation of the situation.

4 Conclusions

There is often some uncertain information related to situational awareness and some of it can be safety-critical. Usually, the rule is to keep the system safe by avoiding use of uncertain safety-critical information. However, in many cases additional uncertain information may improve safety. Such cases can be for example:

- Uncertain information from sensors with long detection range and low reliability can give important information before actual safety function is needed to avoid collision.
- Many AMRs have e.g. safety laser scanners to ensure basic safety cases at specific height, but additional sensors despite low PL may be needed to detect objects, with unusual dimensions and height.
- Devices, which have too low PL cause uncertainty, but additional redundancy may still be useful. This approach may be needed if there is no commercial equipment for the specific environment or situation that can fulfill PL requirements. For example, detection range may be too short, or calculating capacity inadequate for e.g. image processing. Difficult environmental conditions are more common in outdoor applications but in some cases e.g. temperature, moisture, vibration, or lighting may cause limitations to indoors applications.
- Disturbances related to e.g. communication, lighting, and electro-magnetic radiation may cause uncertain information and the solution to improve situation is often case-dependent.
- Uncertain information can be related also to a broken machine and to question is it safe to drive it. For example, if the machine is at a place, where it can cause danger, it must be removed on specific conditions, like applying reduced speed.
- Malfunction of traffic control or warning system reduce situational awareness of persons. E.g., failed traffic light increase risk since persons may receive wrong information. The situation is better when the persons know that the information is uncertain (unknown certain vs. certain unknown).

As seen, there are many causes for uncertain information. Risk assessment is a suitable tool to estimate if the uncertain information is acceptable [5]. In some cases, the uncertain information may exist for a specific time, in a specific operation mode, load or in specific situation. One option to deal with uncertain information is to dynamically adjust speed, direction and separation distance to hazardous location according to the received sensor information. However, complexity increase uncertainty since the probability of errors is higher. Anyway, adequate level of safety can be achieved by increasing redundancy and accepting uncertain information in a controlled manner.

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5 References

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