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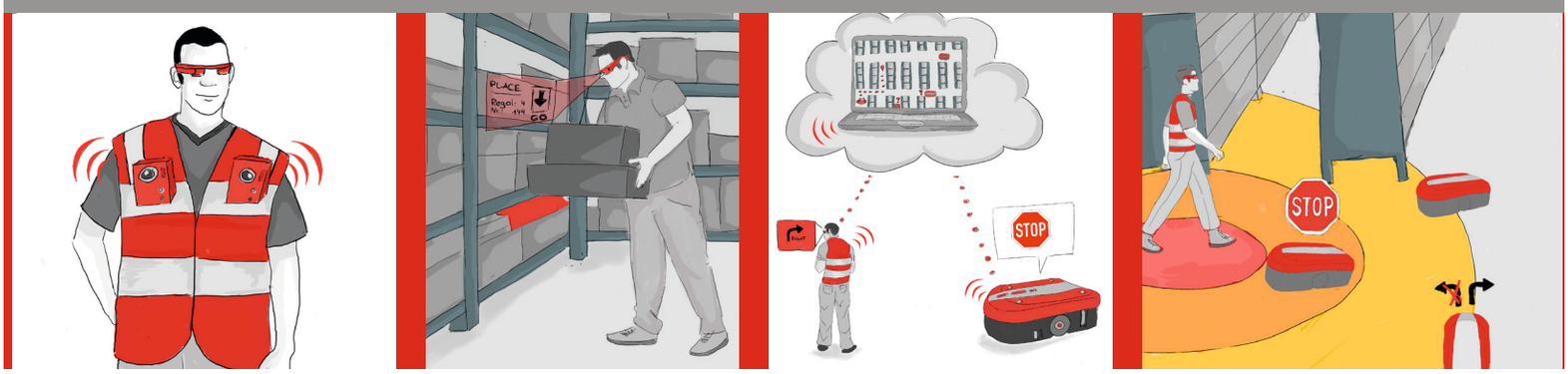

SafeLog

SAFE HUMAN-ROBOT INTERACTION FOR HIGHLY FLEXIBLE WAREHOUSES

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SafeLog Story:

Mr. Pick is storage worker in warehouse having an area of several thousand square meters containing up to 7.000 racks with of different goods. However, Mr. Pick is working in a highly automated and innovated warehouse. He does not have to walk to the racks to pick the goods for shipment. The racks are transported to him by some hundreds of Automated Guided Vehicles (AGVs). He is usually standing at a fix pick station collecting the goods for the orders. The packed orders are transported by forklift AGVs to the goods issuing department. As the warehouse is very huge the pick stations have been placed in between the racks to minimize the travel distance for the racks. This special design of the warehouse is only possible because it is safe for Mr. Pick to walk through the warehouse without colliding with AGVs. This safety is ensured by a safety-vest that Mr. Pick wears. The safety-vest is a device that issues a signal that makes the AGVs aware of Mr. Pick within their vicinity. AGVs will slow down or even stop, so that Mr. Pick can safely reach his workplace. Sometimes Mr. Pick has to fulfil a special order, for which it is faster to walk to the goods instead of getting it from the AGVs. For this purpose, he wears special glasses that show him the way to the racks and which goods to pick. The way through this labyrinth of racks is augmented into his view. Additionally, he can see the AGVs even those which are covered by rows of racks. In this way Mr. Pick always feels safe and does not get lost in the similar looking streets of racks. The same technology is used by Mr. Sertech. He is a service technician. When an AGV breaks down, he has to enter the warehouse, localize the AGV with his glasses and repair it. The feet-manager-system that controls all the AGVs, supports him, by calculating trajectories

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of other AGVs so as to keep the area free from AGVs. Mr. Pick and Mr. Sertech are now happy to work in such an innovated warehouse. And they feel totally safe working together with the AGVs.

SafeLog Vision

When it comes to automation safety is always a key factor. To ensure that no human comes to harm by machinery there are basically two concepts. The easiest way is to keep humans completely separated from automated area during the operation of the system. This is done by sophisticated safety measures such as laser barriers or light fences as well as a solid fence around the system area. Whenever this safety barrier is breached the complete system, or parts of it, are shut down, stopping the operation of the system. In logistics the concept of full automation is not desirable and not even feasible. Thus the vision of Warehouse Co-workers becomes more and more important to advance automation as an assistant system to the human worker. SafeLog's vision is to develop a large-scale flexible warehouse system which enables a safe and efficient collaboration of humans and Automated Guided Vehicles (AGVs) with heterogeneous skillsets in the same area and at the same time.

SafeLog System

The SafeLog system develops a holistic and certifiable safety concept based on a safety vest, which allows the collaboration of AGVs and humans. Strong emphasis is given to planning and scheduling algorithms for a heterogeneous fleet manager. Augmented reality based interaction strategies are developed to support workers in a robotized warehouse system.

The Safety concept

SafeLog introduces a completely new integrated safety concept which will fundamentally change the usage of mobile robots like AGVs in an environment where humans and AGVs work closely together. The concept consists of a 3-layered safety system where the most outer layer – Level C – will try to prevent human-robot encounters by optimal routing of AGVs and humans, Level B will warn humans and machines about possible encounters that could not be prevented by Level C and ultimately Level A will shut down the specific AGV and ensure functional safety when Level C and B failed to prevent an encounter.

Safety Vest

To maintain safety for the humans, while they work in close collaboration with AGVs, a mandatory Safety Vest has to be worn. Equipped with sensors it enables to locate the human and to communicate with other systems.

Fleet Management System

The Fleet Management System (FMS) is a multi-objective, multi-constrained, large-scale planner with additional error handling subsystem (monitoring, diagnosis and maintenance) and lifecycle system-management subsystem (reorganization, flexibility, setup). It is responsible for the coordinated and goal oriented path planning for heterogeneous entities like different AGVs and human workers as well as for scheduling their tasks.

Augmented Reality

Augmented Reality (AR) based wearable devices like glasses will be used to assist the human worker in his different roles by providing picking, navigating and maintenance information. With all AGVs and humans having their predefined trajectories they need to follow, augmented reality based wearable devices will be worn by human workers to provide him with context sensitive information and alarming them about close moving objects and their targets. To ensure high level of interaction between AR and human the system will focus on solving: a) high precision 6DoF head localization; b) human intention recognition; c) human awareness of other AGVs.

SafeLog Impacts

This project will lead to reduction of system wide downtimes by introduction of advanced motion planning by scalable, heterogeneous path-planning methods, integrating humans and AGVs into a generalized concept. Ubiquitous localization methods will allow safe interaction between humans and AGVs.