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Feasibility study of a certifiable production environment using safe environmental sensor systems

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Abstract. *Safe robot development is based on three factors: safety, performance and economy. Currently however, only two properties can be maximized at once, which is why an alternative for maximizing all three factors has been worked on. In particular the topic of safe environment has been discussed, where sensors from individual robots will be relocated in the environment. A sensor thus monitors more than one robot, which leads to an increase in efficiency. Due to the novelty, technical and legal requirements of such a system have first been clarified. The required components have then been determined in order to plan a possible implementation. Finally an adapted concept for the Digital Factory of the UAS Technikum Vienna showed the feasibility of a safety-certifiable environmental sensor system.*

1. Introduction

The fourth industrial revolution is characterized by a flexible production of individual products, which will be ensured by interconnected smart components and robots [5]. However, robots of the third industrial revolution are not flexible enough for this task due to their stationary location. For this reason they are accompanied by mobile robots, which enable a higher production flexibility [3]. These robots will further relieve human work forces from monotonous work allowing them to work on more complex tasks [2]. A combination of human flexibility and robot repeatability thus represents the future of production, whereby safe cooperation must be guaranteed. Furthermore, appropriate changes in intelligent production systems are recommended due to an expected compound annual growth of 23.1% between 2018 and 2023 in the area covering technologies of the fourth industrial revolution [4].

2. Current Solutions and Motivation

Development of industrial and mobile robots is based on three factors as shown in Figure 1. However, current concepts only manage to maximize two of the three properties at once. As safety should never be neglected in a factory, there are two possible configurations: Either expensive systems or cost-efficient approaches with weaker performance [1].

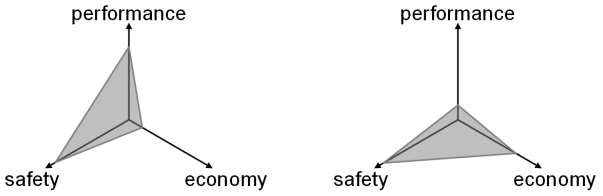

Figure 1. Factors of common robot development

The motivation of this work is the maximization of all three properties in development of safe robotics. A promising solution would be the relocation of individual robot sensors into the environment. The basic idea is that one sensor can monitor several robots and therefore fewer sensors are needed.

3. Basic Requirements and Methods

As there is no safe environment system available yet, technical and legal requirements have to be researched for safety certification in Austrian enterprises first. However, applicable documents differ in each case and experts (e.g. TÜV AUSTRIA, labour inspectorate, etc.) should be consulted for support. Afterwards suitable components of the three identified key elements of sensor systems, processing units and communication modules have to be researched and compared. Subsequently concepts with these requirements and components have to be created and a value benefit analysis should determine the best one.

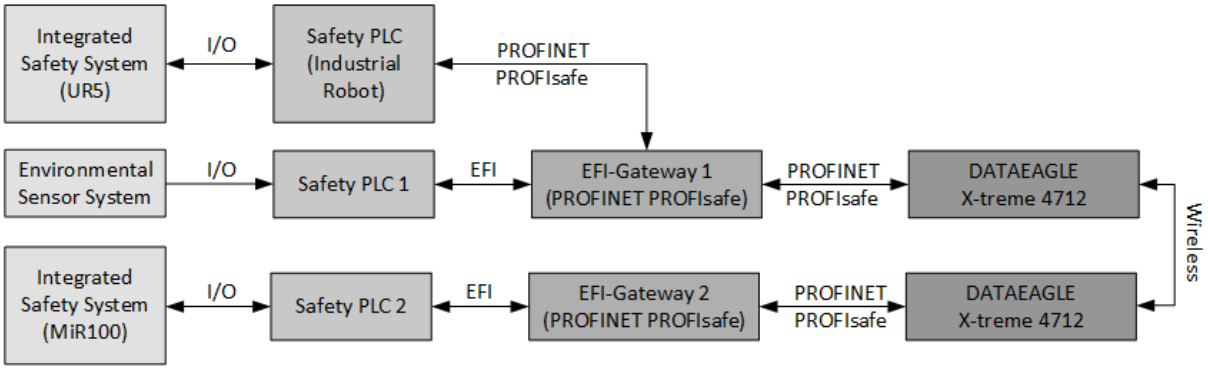

Figure 2. Connections between all components for the safe environment

4. Concepts of a safe environment

A common safety concept (Concept 1) using separate sensors in each robot represents the state-of-the-art [1]. The total close-down of the factory (Concept 2) is another option, but entrances must be monitored to guarantee that no human can enter the working factory. People may only enter after switching the factory to a collaborative mode or a safety stop. If there were people working in the factory regularly, a division of the factory into different segments (Concept 3) would be better. Only segments in which persons are located have to work in collaborative mode, making this concept more efficient. However, this concept is not optimal with many people working in it either. Consequently monitoring the whole environment with active (Concept 4) or passive (Concept 5) person detection is recommended. Workers have to wear a transmitter on their body for the active variant which is not required in the passive detection.

5. Results and Discussion

Safety-certified components are already existing for the first three concepts, but not for active/passive detection. However, the first concept by purchasing safety-certified components for each robot would also be the most expensive concept. Active/passive person detection also requires various components to be installed throughout the factory. Only the second and third concepts would require few sensors at the zone entrances, making them very economical but also inefficient with a high volume of people.
Based on these facts and the emphasis on safety, economy and performance, the third concept was chosen for an implementation in the Digital Factory. Of course, the optimal choice depends above all on the size of the environment and the number of robots.

6. Summary and Outlook

Based on these results a detailed safe environment implementation for the Digital Factory has been planned, where the safe communication (shown in Figure 2) represents the centerpiece of the system: Environmental sensors have thereby been connected to inputs/outputs of a safety PLC, which is further connected to the other safety PLCs via PROFIsafe by PROFINET. However, already existing PLCs do not had a PROFIsafe interface, which is why EFI-gateways have been included. Furthermore special DATAEAGLE modules are required for a safe wireless connection to mobile robots.

A realization of the safe environment is therefore actually possible, but the safe environment concept will probably only become a serious alternative with the development of safety-certified components for active/passive human detection.

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