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An Early Stage Planning Method for Robot Systems

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Abstract

Industrial robots in combination with their peripherals represent flexible, versatile and cost efficient automation systems. Especially small and medium sized enterprises (SMEs) often need additional support regarding the technical and economical evaluation of such systems. Furthermore, there is a lack of knowledge regarding automatable processes and corresponding peripheral devices. For this purpose, a method is developed that allows SMEs to assess automatable processes, their investments and benefits in the early planning phase. The paper presents a methodology for the planning of robot systems in an early stage and details of one step.

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1. Introduction and motivation

Current global trends, which lead to more and more individual products, such as the increasing consideration of customer requirements pose new challenges to production and production systems. One challenge of individual products are decreasing lot sizes. This leads to a demand for flexible and adaptable production systems. [1]

The industrial robot as a flexible production assistant therefore becomes increasingly important. Not only in large companies the application of industrial robots is playing an essential role, also in small and medium-sized companies (SMEs) that sometimes have to handle small lot sizes and a high variety, it is becoming increasingly important [2]. The current statistics of the International Federation of Robotics (IFR) show that about 40% of all industrial robots are used in the automotive industry and about 20% in the electronic industry [3]. In both sectors, the robot is mostly used in mass production for special operations, such as screwing or welding in 3-shift operation, and is reprogrammed rarely to never. This can be quite different in SMEs, in which the robot is needed for one task only a few hours and afterwards for another task. In this case, the flexibility plays a central role. [2] Especially for companies that aren't concerned with industrial robots but are facing constantly changing or varying products, it is often difficult to assess whether an investment in a robot is profitable from an economic and entrepreneurial perspective. For SMEs profitability of an investment is very important because their capital base is usually small and the asset in the machine is bonded and reduces the liquidity of a company. In addition, the necessary planning capacity in SMEs is not always available for the evaluation and purchasing of complex robot systems. The request of companies not to discuss any idea with a contractor is adverse to this [2].

The complexity according to [4] can be assessed by four criteria. These are diversity, multiplicity, ambiguity and variability. [4] Concerning robot systems, **diversity** on the one hand reflects the possibility to contain different peripheral components, on the other hand, different robot types can be used for the same process. **Multiplicity** largely results from the amount of components required for a robot system to solve one task. **Ambiguity** is reflected by the different solutions for one problem, such as checking the presence of a part by mechanical contact switches or optical sensors. **Variability** on

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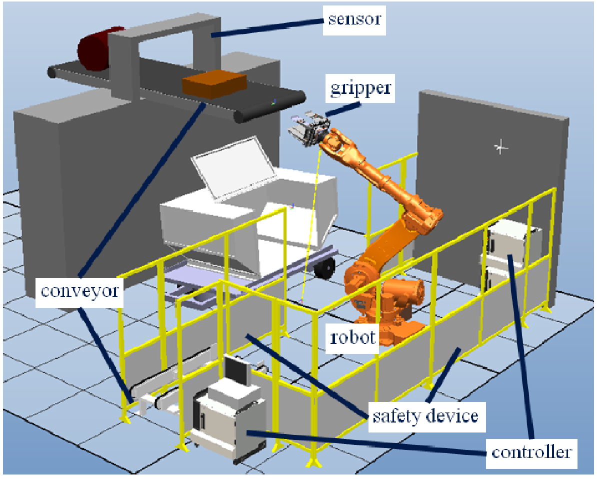

Fig. 1. Example for a robot system with various components.

the one side is given by the margin of products that are processed by the robot system and on the other side by the changing of peripheral components and their functions. Fig. 1 shows an example for the complexity of a robot system: the automated loading of suitcases at an airport. Different sensors for the presence control of the suitcases are possible. Also the safety fence can be replaced by e. g. a laser scanner in future scenarios. The robot has its own control while the whole system has an additional controller. The complexity of robot systems has caused the development of system integrators for planning such systems, which have specialized either in robot manufacturers or applications. Other companies have specialized in the development of customized peripheral components for robots.

2. Planning of robot systems

Known planning methods that are used for normal machine tools cannot be applied for industrial robots, because certain planning steps in the design of a robot system must be weighted differently [2] and partially adapted. Already in the 1980’s [5] recognized that the planning of robot systems requires a systematic procedure and developed a method for the task-based design of robot systems. The application of this method mainly takes place in handling operations, which was prevalent at that time. The planning of robot systems includes different steps, according to [5], which are being iterated while planning, a system analysis which is summarized in a system specification, as well as the steps of layout planning, equipment selection and peripheral design. Furgac developed a form for the selection of work stations that could be automated with the help of industrial robots. Finally, Furgac performs an economic evaluation of robot applications. [5] Since in recent years the development of both, the industrial robot and the peripheral components, made progresses (e. g. more functions, new devices, new applications, new types of robots such as delta robots, a huge number of robots on the market), the planning of robot systems has become more complex and the boundary conditions as well as the applications increased in diversity.

According to [6] the development of technological systems consists of seven steps. These steps can be passed in parts or repeated if necessary. The first step is the requirement analysis. This step is followed by the identification of functions. Further steps include the quest for and the detailing of solutions up to a realized product.

Today's planning approaches for industrial robots also use the elements of [5, 6] and include a brainstorming, an examination of the technical feasibility, the layout planning, as well as an economic analysis [2]. The layout planning is usually supported by simulation software, which usually requires experts [7]. All planning processes that are based on checklists and questionnaires, can serve as a support for investment decisions [2]. However, these aids are sometimes very specific and cannot be used by inexperienced decision-makers. Furthermore, they only partially cover the conditions of production, such as the environmental influences (noise, dust, etc.), without referring to specific products and processes.

In the early planning phase, in which an investment decision takes place, the plant design is rarely supported by IT tools [7]. Due to the complexity of planning, expertise is inevitable for the design of robot systems despite all methodological approaches [5]. Therefore planning results are mostly based on the experience and knowledge of experts [7].

3. General structure of the method

In order to reduce SMEs dependency on experts in investment decision (like system integrators) a method is developed which supports decision makers to estimate the efficiency and the level of investment in a robot system with