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Integration of a PID Control System for a Mobile System for Manufacturing Task on Continuous Conveyor

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Abstract: In this paper, we will introduce a new concept to reduce the non value added process in the manufacturing industry. This concept is based on the combination of transportation and machining tasks with mobile robots. The reason behind this concept is to reduce the waste of production time, cost and effort. To realize this concept, a demonstration system has been built. The first step to accomplish this system is to synchronize an automated guided vehicle (AGV) to a moving object. The position data of the AGV and the moving object are collected by using an optic measurement system and used to control the movement of the AGV. An external control system including a Proportional–Integral–Derivative (PID) controller has been built to control the AGV. Experimental validation was performed using an AGV and an optical measurement system for the proposed control system. The results show that the accuracy of the optimized control system has been improved in comparison with the control system without the use of the PID controller.

Keywords: Mobile robot, manufacturing task, continuous conveyor, industry, PID controller.

1. INTRODUCTION

The reduction of the ratio of the non value added processes is always one of the most important aspects for optimization of manufacturing (Werner, 2008). This is important because if the non value added processes can be reduced, the waste processes of production time, cost and effort can be reduced significantly (Sullivan, 2002).

A large part of the obstacles for the improvement comes from the non value added processes such as transportation etc. Transportation plays a big role when it comes to manufacturing, but it is usually independent from the production processes, and therefore the utilization of the costs and time during transportation is not very efficient. This is a large waste of time and costs.

Furthermore, in recent years the focus of the research concerning manufacturing has been placed on the flexibility of the production chains. There are a lot of reasons for improving the flexibility. One of the most important reasons is to achieve a higher degree of automation in manufacturing, which means that more robots will have to be integrated into the manufacturing processes. Therefore, improving the flexibility is important to ensure a quick deployment and displacement of the robots.

Currently, the conventional processing stations and fixed robots are generally used in conventional industry for manufacturing tasks. For this reason, the transportation is still a necessary part of work among the stations. Usually, the existing fixed robot cannot keep performing processes on the work pieces during transportation, and this causes a waste of time and costs without any processing being performed. Therefore, this waste has to be avoided (Sullivan, 2002). As a result, a new concept has been developed to solve this issue of wasted time and cost with a mobile robot executing the manufacturing tasks on the moving work pieces alongside the continuous conveyor during the transportation as described previously in (Berger, 2015).

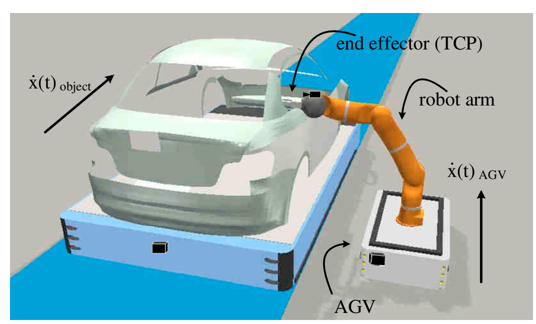

Fig. 1. The mobile system for manufacturing task on a continuous conveyor.

Based on the aforementioned reasons, a mobile robot system (Fig. 1) executing manufacturing tasks during transportation is taken into account. The system will be achieved with the following steps:

1. The synchronization between the mobile platform and the mobile object.
2. The synchronization between the mobile robot's end effector (mobile platform and robot arm together) and the moving object.
3. The mobile robot executes manufacturing task on the continuous conveyor

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The motion of the object and the robot's end effector (TCP) has to be synchronized to one another other. The speed of the object usually depends on the speed of the conveyer in most cases. Therefore, the position of the TCP has to be controlled accordingly to compensate for the deviation between the positions of the TCP and the object. The position of the TCP can be controlled by:

- Mobile platform control
- Robot control

Because of the demanding manufacturing process schedule, it is impractical to change the speed of a fixed conveyor frequently. For that reason, it is preferred to control the speed of the mobile platform, so that the mobile platform can be synchronized to the moving object on the conveyor. This paper aims to present a mobile platform (first step) which is synchronized to a moving object and keeps the object in the robot's workspace. A mobile platform control system has been installed for an AGV and the synchronization between the AGV and the moving object is tested with it in our laboratory (Berger, 2015).

Previously the deviation between the moving object and the AGV was not a relevant value in the original control system of the AGV, so it is difficult to achieve the synchronization between the moving object and the AGV. For that reason, a control system should be developed relative to the position of the moving object. A control system using the PID controller is developed in order to achieve a stable synchronisation between the moving object and the AGV.

The synchronization between the AGV and the moving object is realized through regulating the speed of the AGV. Fig. 3 – left shows the AGV KATE, the AGV consists of two motors for the two drive wheels in the front that are controlled by an existing drive module. The PID control system will focus on regulating the speed of the AGV in order to synchronize it to the moving object.

In this paper, the development of the integration of the PID control system will be presented, and the reduction of the deviation between the mobile robot and the moving object will be further evaluated.

This paper is structured as follows:

Section II: the state of the art regarding performing the manufacturing tasks by variant robots.

Section III: a general architecture of the system will be explained.

Section IV: the development of the PID control system is presented afterwards.

Section V: the experiment results will be evaluated and discussed.

Section VI: some conclusions of the work will be given and future work will be introduced.

2. STATE OF THE ART

This paper presents a concept of a mobile robot system for performing manufacturing tasks on a continuous conveyor. To evaluate the state of the art in this field, a survey is carried out and three different methods of performing assembly tasks using industrial robots are reviewed:

1. A fixed industrial robot tracks the moving object on a continuous running conveyor,
2. an industrial robot constructed on a linear axis moves alongside a continuously moving object and performs assembly tasks, and
3. a mobile robot that calibrates itself automatically to a fixed station after reaching the station and performs assembly tasks.

The review of these three methods can be divided into the analysis about the components and the application as well as the purposes. With the study of the existing methods and concepts, the derivation of the proposed system in this paper will be described.

The components of the robot system which are used to perform assembly tasks during movement can be divided into three parts, which are the robot and the sensors on the robot as well as the platform to make the robot movable. On robot's side, the conventional industrial robots are still currently the most popular robots in the industry. Therefore, a lot of work has been done to make use of the conventional robot. To synchronize the end effector of a fixed robot to a moving target, tracking systems with variable sensors are used frequently. By using sensors, the robot can obtain the object's position in real time. Based on that, some systems synchronize the robot's end effector to moving objects by measuring and tracking the object's position (Shin, 2006, Meyer, 2006 and Reinhart, 2009). However, the range of the robot's workspace is finite and the continuously moving object cannot always stay in the robot's workspace. Furthermore, the assembly tasks take usually more time and steps. It's difficult to finish the whole task during the object's movement.

Another system which uses a conventional industrial robot consists of a continuously running conveyor and a movable robot to perform wheel assembly onto a car body (Lange, 2010a). In this system, the robot is of a large scale. To make the robot movable, the robot is built with a linear axis which is parallel to the conveyor line but fixed on the ground. With the high stability and accuracy of both of the robot and the linear axis, the robot can move finely forwards and backwards in the range of the linear axis, so that the robot can move alongside the car body with an almost identical relative position. However, the disadvantage of the linear axis that was observed is that the linear axis is fixed on the ground and therefore, the range of the robot movement is restricted. Another disadvantage is that the conventional industrial robot is usually of a relatively large scale and also very stiff. Therefore, the conventional industrial robot is not suitable to work in a small workplace or cooperate with a human workforce. Furthermore, it's difficult to build a mobile platform for the conventional industrial robot.