technische universität dortmund

Dept. of Biochemical- and Chemical Engineering

Diplomarbeit / Masterarbeit

High-level Hierarchical Control of a Miniature Pipeless Plant with Mobile Robots

Introduction:

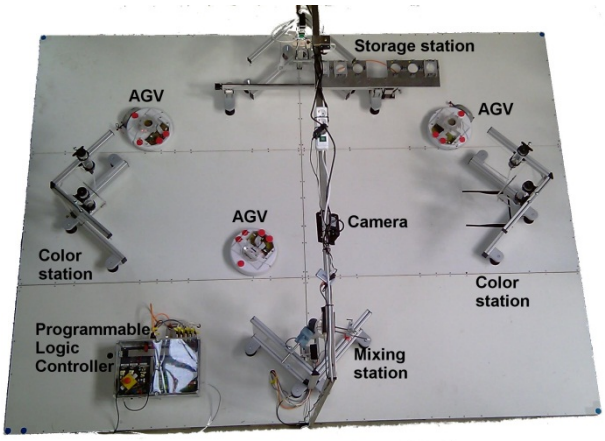

Fig. 1: A miniature pipeless plant.

Due to their high flexibility, pipeless plants are used in chemical industries to produce high-valued products in small quantities, e.g. pharmaceutics or other fine chemicals. Fig. 1 shows a schematic view of a miniature pipeless plant which was developed and built at the Process Dynamics and Operations Group in the scope of the European research project MULTIFORM [1]. Instead of using complex pipe layouts, the transport of the raw and intermediate materials is carried out in mobile vessels using wireless controlled vehicles, so called *Automated Guided Vehicles* or AGVs.

The miniature plant produces multi-layered, colored chalk cylinders. The process steps are executed sequentially at different, fixed processing stations. Each color layer is produced in three different steps:

(1) Dosing of different liquid colors at different color stations

(2) Adding of gypsum and blending in a mixing station

(3) Hardening of the chalk in a storage station

Objectives:

In the scope of this thesis a more efficient high-level hierarchical control of the plant has to be developed by upgrading the existing TA-based scheduling routine [2] to a reactive scheduling framework based on a moving window approach [3] that interacts with an advanced route planning of the vehicles. The dynamic route planning is used to deliver an accurate estimate for AGV movement times. Prior studies showed that potential fields are very promising candidates for dynamic route planning.

The controller to be developed should be able to react to disturbances such as movement delays, unplanned stopping of AGVs, station malfunction, etc., and implemented in the existing control framework.

Steps:

a) Familiarization with the existing *software control system*, the routing and scheduling modules, TA-based scheduling, reactive scheduling, and the AGV motion control.

b) Development and implementation of a high-level hierarchical control algorithm for the MULTIFORM pipeless plant.

- Development of a dynamic route planning for multiple AGVs
- Development of a reactive TA-based scheduling of the production tasks
- Synchronization of the scheduling and the AGV route planning
- Connection of the developed controller to the low-level AGV motion and station controllers

c) Testing of the hierarchical control algorithm on the real plant to demonstrate the enhanced behavior.

d) Written documentation of all developed methodologies, all results of the application to the example process, all developed software modules, and all other results of this thesis.

Literature:

[1] MULTIFORM (2008). Integrated multi-formalism tool support for the design of networked embedded control systems. http://www.ict-multiform.eu. EU-funded research project, contract number INFSO-ICT-224249.

[2] Schoppmeyer, C., Hüfner, M., Subbiah, S., and Engell, S. (2012). Timed Automata Based Scheduling for a Miniature Pipeless Plant with Mobile Robots. 2012 IEEE International Conference on Control Applications (CCA), 240-245

[3] Subbiah, S., Schoppmeyer, C., Valdes, J. M., Sonntag, C., and Engell, S. (2013). Optimal Management of Shuttle Robots in a High-rise Warehouse Using Timed Automata Models. Submitted to: IFAC Conference on Manufacturing Modelling, Management, and Control (MIM-13) 2013.

Requirements:

For the implementation part of this work knowledge in object oriented programming languages (e.g. C#) is obligatory.

Start and duration:

As of now, 6 month full time

Contact:

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