Design and implementation of model-based controllers for baggage handling systems

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Introduction
Vanderlande is a leading manufacturer in the industry of baggage handling systems. Developing control software for these systems is a challenging task. Controllers are coded based on textual requirements and testing is mainly done after coding the controller.

Approach
In this project, a new approach for controller design is applied. This approach is shown in Figure 1. The approach consists of three parts: design, validation and implementation. In the development process the Compositional Interchange Format (CIF) and its tooling is used. CIF is a formal modeling language for hybrid automata. The tooling offers visualization, simulation and automatic code generation for models specified in this language. The tooling is available for free at http://cif.se.wtb.tue.nl.

Validation
Diagram of the validation approach.

Design
Controller model (CIF)
Actuators
Sensors
Hardware model (CIF)

Implementation
Code generator
Siemens Controller code

Figure 1: Approach for controller design

Test Loop
The test loop for which a controller is developed is shown in Figure 2. The loop consists of approximately 50 conveyors with a total length of 120 meters. The loop allows for testing of many functionalities, such as sorting and merging of baggage flows. The systems is structured in three levels: Area, Zone and Section.

Figure 2: Schematic view of the test loop

CIF Model
The requirements for the system are specified in a CIF hardware model and a CIF controller model. Specifying requirements in CIF models has many advantages: Models are easy to understand, can be simulated for validation and are control platform independent. The developed models have a modular design. Each part can be reused in another model and models can be extended easily.

Validation
The CIF model is validated using an interactive simulation based visualization. This visualization can be automatically generated from the CIF model. The visualization allows for testing and fast debugging, early in the design process. An example is shown in Figure 3. The figure shows a top view of eight conveyors. The user can control the visualization with the buttons on the right.

Real Time Implementation
Model transformations are developed and applied to the controller model, and controller code for a Siemens PLC is automatically generated. Validated properties in the CIF model are preserved. Also the modularity of the CIF model is preserved. Real time testing of this generated controller showed that the developed models were a good abstraction and that with the validation, only a small test effort is required for the implementation.

Conclusions & Recommendations
The approach used in this project can improve the design cycle for controllers developed by Vanderlande. The approach allows for requirement based modeling, early testing, visualization based validation and automatic code generation. The tools used in this approach are a proof of concept and should be developed further before they can be used in industry.

Figure 3: Interactive simulation based visualization