Automatisierter Softwaretest mittels HiL-Technologie

Dr. Thomas Neubert
Geschäftsführer, HYDRIVE Engineering GmbH, Hirschstein
Dr. Rocco Deutschmann
Geschäftsführer, TraceTronic GmbH, Dresden

Kurzfassung

Robuste und zuverlässige elektrohydraulische Ventile, Pumpen und Motore sowie immer leistungsfähigere elektronische Steuerungen und Sensoren führten in den letzten Jahren zu einer schnellen Verbreitung elektrohydraulischer Antriebssysteme in mobilen Arbeitsmaschinen. Mit der zunehmenden Komplexität der Maschinenfunktionen steigen die Anforderungen an den Entwicklungsprozess, insbesondere Softwareentwicklung. Der Beitrag geht auf die Besonderheiten der Softwareentwicklung für mobile Arbeitsmaschinen ein. Automatisierte Softwaretests mittels HiL-Technologie haben sich als Basis der Softwareentwicklung in der HYDRIVE Engineering GmbH etabliert und leisten in verschiedenen Entwicklungsstufen einen wichtigen Beitrag, mit dem den gestiegenen Anforderungen begegnet werden kann.

Abstract

Robust and reliable electro-hydraulic components like valves, pumps and motors as well as electronic control units and sensors disseminate more and more in the field of mobile machinery. With the increasing complexity of machine functions, the requirements for the development process also grow, especially in software development. This paper addresses specific aspects of software development in mobile machinery environment. Automated software test by using HiL technology has been established as a basis of software development at HYDRIVE Engineering GmbH and plays an important role in meeting the increased requirements of software development for mobile machinery.

Introduction

The intensive competition between mobile machinery companies in Europe and the US on one side and upcoming manufactureres in the Far East like China and India on the other side has for many years lead to a high cost pressure. Functional aspects such as flexibility and simplification of machine handling are drivers for a growing use of electro-hydraulic components like pumps and valves.

The consistent application of electro-hydraulic systems allows machine manufacturers to develop new control and operating concepts and consequently to achieve cost targets of their customers.

By transferring assigned functions, e.g. synchronous movements, to the software, the number of mechanical and hydraulic components and thereby costs can be reduced. By combining simplification and standardization of hydraulic components for different machine sizes and platforms with a differentiation of machine behavior by software, further cost potential can be exploited.

Communication between electronic subsystems of engine, transmission and attachment hydraulic can develop new possibilities of higher-level functional integration, e.g. drive line controls for optimization of energy consumption /1/. Productivity can be increased significantly by combining automated control systems with completely new operating concepts such as tracking systems and blade height control systems /2/.

However, control software represents a large extent of the machine functionality and has already been established as an important part of mobile machines. Therefore, the significance of software development in mobile machinery will increase.

Trends and Specifics in Mobile Machines

Figure 1 shows the development of electronic subsystems in mobile machines. Just a few years ago, isolated applications have dominated, for instance electronically controlled power shift gears, electronically controlled engines, and electro-hydraulic valves and pumps directly controlled by joysticks with PWM outputs. Software functionality was limited to the components itself and therefore less complex. Software was located mainly inside component controllers.

Today, those components are controlled by one or more machine control units, to reduce fuel consumption by drive train management or to control assigned machine functions related to their priority and power demand. The machine operator can reconfigure machine functions and select an assigned machine behavior via colored touch screens, where he can receive monitoring or error messages of the machine. By introducting a central control unit, software complexity has been significantly increased. Because of their huge number of interactions, the communication between central control unit and component microcontrollers is a further driving force for software development efforts.

In future, a tigther cross-linking of data and functions for driver assistance systems is expected to further increase productivity and safety of mobile machines (see Figure 1).

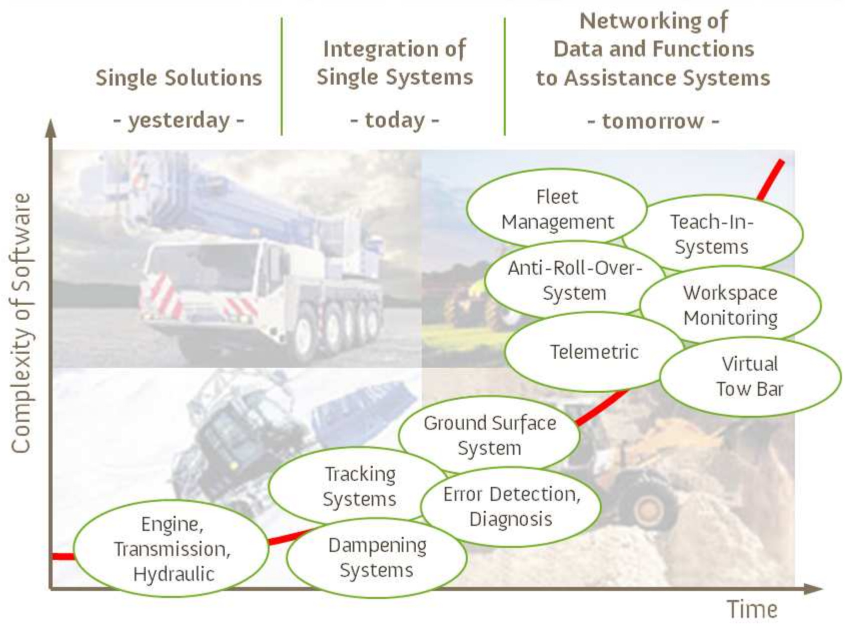

Figure 1: *Development of electronic systems in mobile machines*

The development of electronic systems in mobile machines and their growing functional complexity require the use and adaption of software development processes like automated software testing, which is already used in the car industry. Important reasons for that are the ratio between the array of existing products and available development resources as well as the specific operating conditions of mobile machines.

In a mobile machine, software has the same tasks as in a state-of-the-art car, for instance automotive control, gearbox control, engine control, and control of modern convenience functions. Additionally, there is an interaction between all these controls and the electro-hydraulic attachment control. The following specifics of software development for mobile machines indicate differences to those of car industry or stationary machinery:

- **Operator guidance with open loop control.** By definition, the attachment is controlled in open loop. But in reality, the operator has a clear anticipation of how the machine should behave. It depends on hydaulic system structure and drive dimensioning. Operators don’t accept modified machine behaviors, e.g. changes due to a system for lower energy consumption. The manifold operation possibilities available to the operator, e.g. steering wheel, pedals, transmission lever, joysticks, and switches, lead to a high input complexity that has to be considered in software design.
- **Safety – humans in workspace.** Many machines like cranes, excavators or tractors are used together with workers outside. There is no possibility

to protect humans in the workspace. Therefore, the high safety requirements given by law have to be observed.

- **Quantities.** The quantities of mobile machines amount about 100 to 150 per year, which is much less than in the car industry but much more than in stationary machinery.
- **Equipment options diversity.** To meet the wide range of application scenarios customers have, a plurality of attachment options is offered. For example, an excavator can be used for a crane application with a specific attachment and grab as well as for a digging on a lower carriage for railway application.

Software Development in Mobile Machines

Coming from the state of the art of software development in mobile machines, new processes have to address the following requirements:

- High level of maturity in prototype phase
- Robustness with respect to working conditions and operator handling
- Verification of required safety level
- Fast reuse of development results
- Easy handling of software development processes, methods and tools

Cooperative Research Activity

Within the scope of a cooperative research activity, the companies TraceTronic, ITI und HYDRIVE Engineering are developing a test and validation framework for mobile machines industry, supported by European Regional Development Fund (ERDF). TraceTronic offers powerful software products such as ECU-TEST for test automation of electronic control unit software and TRACE-CHECK for the automated analysis of measured data. ITI provides the simulation tool SimulationX for modeling multi-domain systems. HYDRIVE Engineering develops drive lines and drive components for stationary machinery and self-propelled working machines as well as control software used for drives.

Automated Software Testing Approach

The most important part of any software development is the coding itself. HYDRIVE Engineering uses automated code generation based on MATLAB/Simulink, which is not the focus of this paper. Another important part, however, is test and validation in all phases of software development.

Figure 2: gives an overview of automated software testing by using HiL technology. The basis of each test is a real-time simulation model of the vehicle

that is derived from a non-real-time SimulationX model, which is used for developing machine functions. A real-time model represents the machine behavior, depending on actuator values (valve currents) generated by control software within the ECU. The software ECU-TEST controls the automatic sequencing of the software test. By using ECU-TEST, all test cases can be created, executed, and managed, and test reports can be provided.

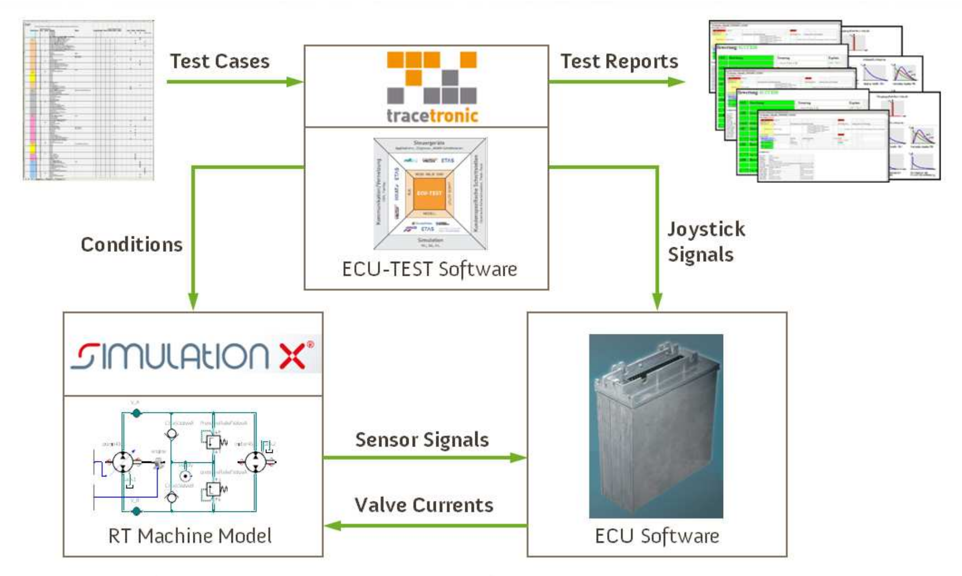

Figure 2: *Overview of Automated Software Testing*

The hardware basis for real-time simulation and signal conditioning is NI VeriStand, a real-time simulation and configuration tool with an open interface for other tools.

Summary

Automated software testing by using the presented test stand offers an important contribution to software development. It is the basis to meet future requirements of software development in mobile machines regarding quality, reliability, and safety.

[1] J. Weber, E. Lautner:
Intelligente Baumaschinensteuerungen und alternative Antriebssysteme
Fachtagung Baumaschinen, Magdeburg, 2004

[2] Autorenkollektiv:
Trends in der Bau- und Baustoffmaschinenindustrie - Beobachtungen anlässlich der bauma 2010. O+P Ölhydraulik und Pneumatik 07+08/2010