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Remote Diagnostics of Robotic Welding Systems

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Abstract

Software packages reviewed in this article serve as tools for remote diagnosis and maintenance. Thus not only a dramatic reduction of overall system downtime, but also an important decrease in service costs becomes possible. Maintenance specialists can remotely assist, diagnose and solve service problems, regardless of the location of the robotic systems.

This article examines two possible scenarios to remotely connect to robotic systems: either through a direct internet connection to the control cabinet of the automated system or through using a computer connected to the common communication network of all robotic systems. The Information systems analyzed contain all necessary functions necessary for a technical revision, maintenance and diagnostic of a robotic system. With standardized functions service personnel can thus carry out remote diagnostics and repairs. Upgrading the operating system, overview of the current system state, and adjustment of the actuators are just some of the options offered by the systems described in the present article.

Key words: *diagnostics, robotic system, remote servicing, internet*

Introduction

Present day robot systems are required to meet stringent production schedules and targets. A malfunctioning of any critical component of the unit often makes this task not only difficult, but even impossible. A prolonged equipment breakdown adversely affects the production output of that unit and sometimes, depending upon the flow of parts in the assembly line, has a negative influence on the manufacturing cells preceding and succeeding it (e.g. car production line).

Reasons for extended down-time intervals range from a lack of necessary training for the operator, tremendous variety and nature of problems that can arise, physical distance of the equipment from available help, to time lapses between occurrence and realization of the existence of a problem. To be able to address the above issues, it would be desirable to continuously and automatically monitor and diagnose problems, just as they occur.

Remote Diagnostics exactly fills that gap. It is the ability to diagnose a given symptom, issue or problem from a distance. Instead of the subject being collocated with the person or system doing the diagnostics, with remote diagnostics, the subjects can be separated by physical distance. Information exchange occurs through a communication channel (usually a network connection, be it wired, optical or wireless).

When limiting to robotic systems, a general accepted definition is: 'to improve reliability of vital or capital-intensive installations and reduce the maintenance costs by avoiding unplanned maintenance, by monitoring the condition of the system remotely. **1**]

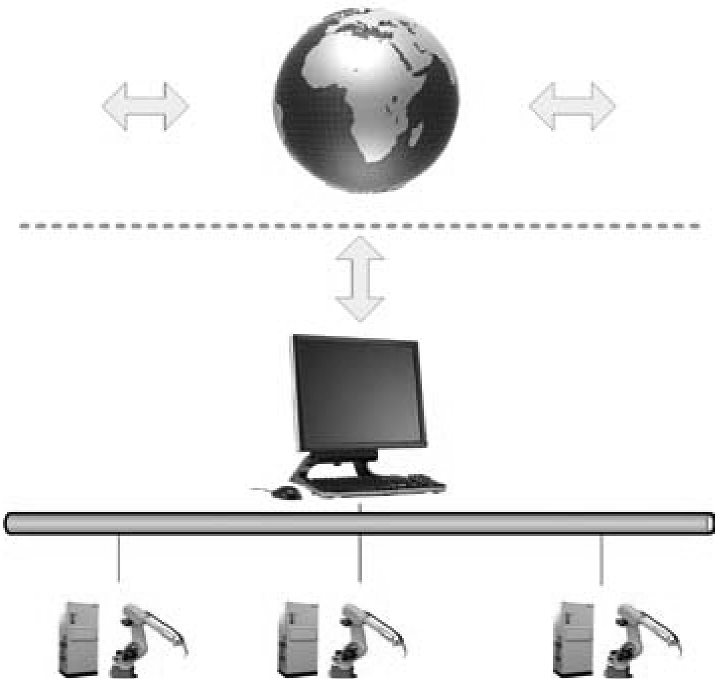

Fig. 1. Typical architecture for a remote diagnotic system

Solutions

Remote diagnostics

Remote diagnostic systems are widely available for computer systems (currently more than 200 available products). Based on the same infrastructure, robot system manufacturers have started applying these solutions to robot controllers and robotic cells.

Remote diagnostics allow service technicians to observe the current status of a robotic system, and perform remote maintenance actions.

Based on the interaction level there can be two types of remote diagnostic systems: active or passive. Passive systems allow only an observer status, while active systems allow the remote service technician to alter the system state by executing actions from the remote location.

Based on the interfacing used remote diagnostics can be either through a direct internet connection to the control cabinet of the robotic system or through using a personal computer connected to the common communication network of all the robotic systems. The second scenario is usually preferred, as the same personal computer is used by the plant service technicians for on-site diagnostics, and by the remote technicians for remote diagnostics.

Remote maintenance

Similar in architecture and interface to diagnostic systems, remote maintenance systems allow the service technician not only to observe the current state of the system, but to cause various actions in order to obtain better diagnostic information, to cause preventive and corrective actions. Some of these are described during the next chapter.

A remote maintenance system won't replace the periodical maintenance work carried out on robotic systems (because hands on actions are required: lubrication, cleaning, etc), but a lot of actions can be carried out remotely these days (measuring voltages, even adjusting power supply units, test system integrity, test system response to various inputs, etc), complete welding- but also motion programs can be transferred from and to the robot **7**] which enables the debugging being executed in a remote location, by far better specialized people compared to those from the factory.

Possible Diagnostic and Maintenance Operations for Robotic Welding Systems

Overview of the current system state

As previously outlined, the most important aspect to diagnostic, repair or maintenance of a robotic system is access to data. Obtaining and understanding the current system state, along with having knowledge how the current state should be allows a service technician or engineer to determine the cause of the current malfunction, or determine possible problems that will arrive in the future.

Robot configuration

As the remote service personnel aren't familiar with every robot system, the robot configuration is the first data point that is collected and looked at. Based on the robot configuration the service personnel know what components are in the system and how they are interconnected. Further analysis actions are based on the component list.

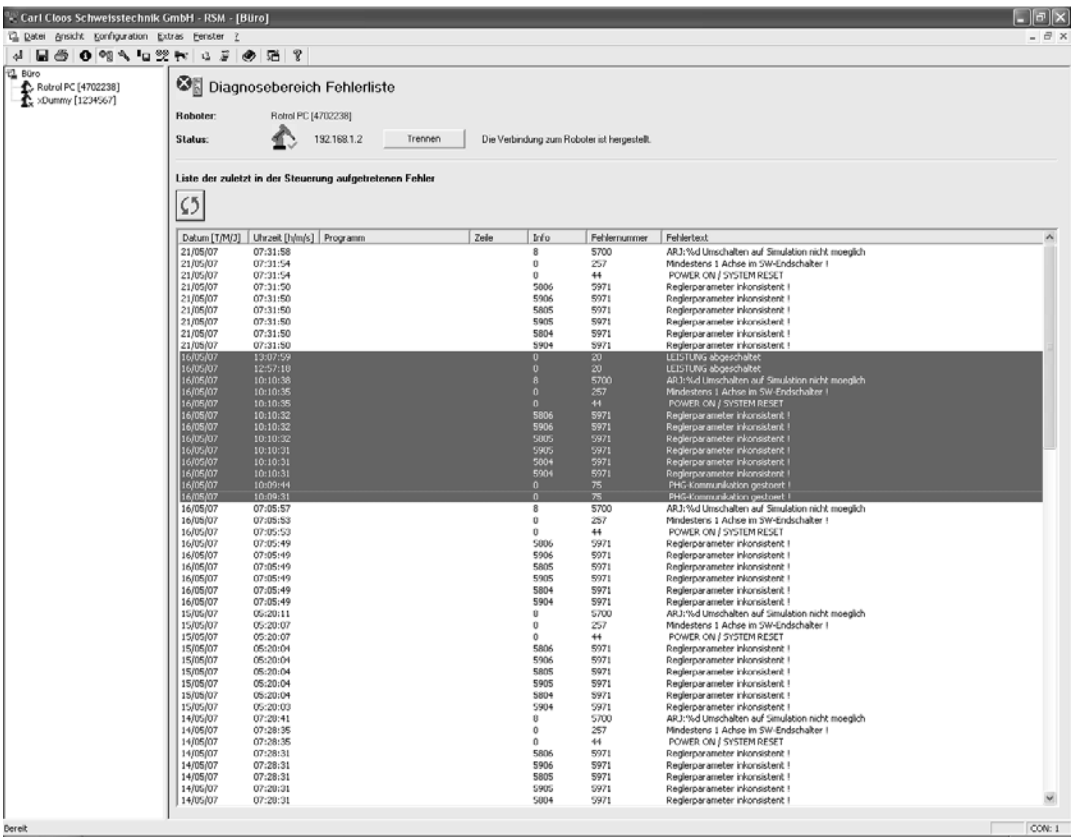

Fig. 2. Current error list

Current error list

Another very important data point is the current error list. Usually the last error is helpful for simple errors. For complex issues however it’s more important to analyze the systems stability by looking at the previous weeks/months. Certain periodic errors are easier to provide clues about the problems at hand.

Internal/external joint status

As the main means for a robotic system to perform actions is using actuators, those are the most important components. Observing the actuators status is regarded as crucial, as a lot of potential problems can be observed before they happen. One can see that motor current increases as bearings lose their grease, even before a bearing breaks down completely. High currents during acceleration / deceleration periods can point to problems with balancers (e.g. pneumatic piston aided joints).

Software version

Robotic systems are constructed of ever evolving components. The supplier changes hardware and software components quite regularly to keep up with technological advances. It is therefore quite important to understand exactly what software components are installed on the analyzed robotic system, various versions can cause different error messages, different reactions to external stimuli.

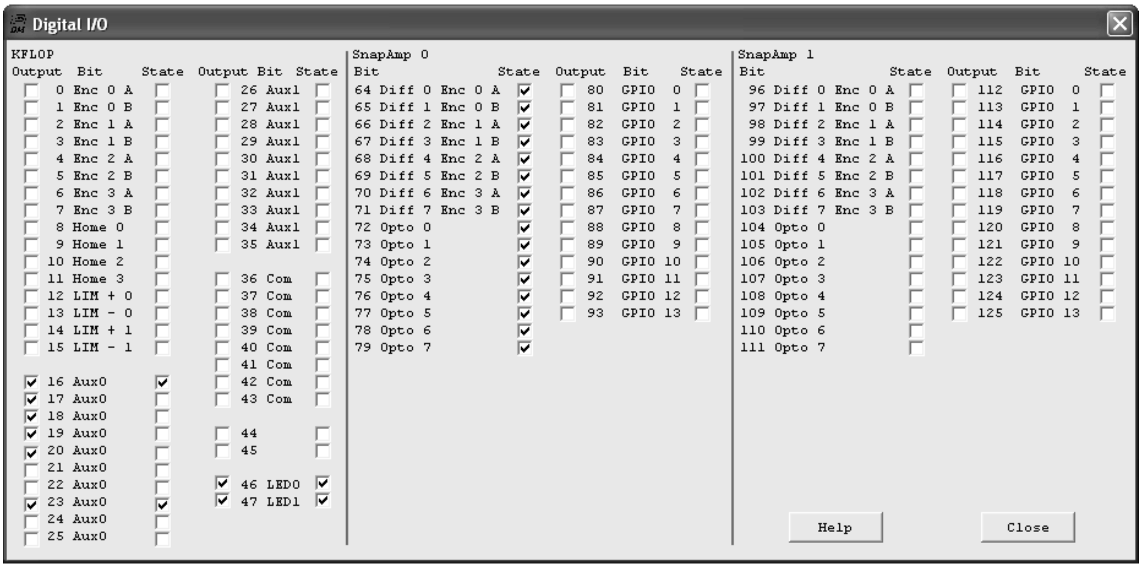

Fig. 3. Digital I/O diagnose screen

Digital inputs & outputs

Another useful data point is looking at the digital inputs & outputs of a robotic system (as seen in Fig. 3). Digital I/O are used to interface with various custom components: automatic fixtures; safety equipment like doors, light curtains, etc; checking part presence; identify part type and many more.

Observing the current I/O status the service personnel can identify faulty sensors, failed execution steps or blocked interactions in production lines.

Transfer of robot programs

Another topic that is commonly used for remote diagnosis and maintenance is the possibility to transfer robot programs. Most remote diagnostic programs allow this [**4**, **5**], as quite commonly the malfunction of the robotic system can be traced to a programming error.

Adjustment of the actuators

If the actuator controller parameters (the gains of the proportional, integral and derivative terms) are incorrect, the controlled process input can be unstable, i.e. its output diverges, with or without oscillation, and is limited only by saturation or mechanical breakage. For a robotic system, this can have pretty serious results: in extreme cases unwanted motion resulting in collisions. Regular operations with badly tuned actuators results in excessive wear of the mechanical components. Tuning the control loop for the robots actuators can be done using the remote maintenance software – usually using a mathematical model of the actuator, and it's response to a step change of the input. [**3**]

Upgrading the operating system

Like their home use relatives, industrial computers are affected by software bugs and problems. As these are discovered new releases prevent them for happening on other systems as well. Software update on the robot controllers is therefore a preventive action which needs to be performed by trained service engineers. Being able to do it remotely, and not dispatch an engineer onsite reduces the time and the cost of the update.

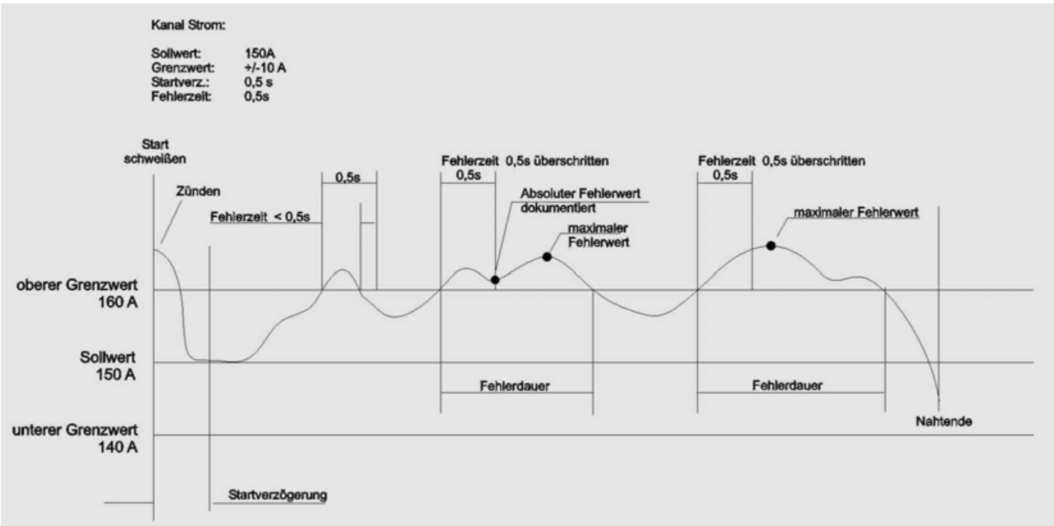

Fig. 4. Welding parameters analysis

Welding parameters analysis

Not only motion related things need to be observed in a robotic welding system. The modern welding equipment also calls for remote diagnosis and maintenance.

Welding machines are interconnected in the customer's plant local network, and connected to the remote diagnostic system. Further on it is possible to analyze current welding parameters, log and observe limit tripping (custom limits can be defined for welding current, voltage, wire speed, gas flow rate, arc stability or many other welding parameter. The system can be configured to record the fault and/or abort the welding process, if those limits are exceeded – as seen in Fig. 4). It is also possible to get statistical data such as: welding time (arc time), inactive time, number of welds, number of seams, individual or total cost.

A cost calculation system allows the definition of consumable prices (wire, gas, electricity and workforce) and is further on capable to calculate the total cost of production (per seam, part, shift, per day, per month, per year). For plants with multiple welding robot systems and equipments it's just a matter of interconnecting all welding equipment and summing up all individual costs. This can be also performed by a host computer at shop or factory level.

Advantages

The main advantage of using remote diagnostic and maintenance systems is to reduce production costs. The cost reduction is manyfold: because less high trained personnel is needed on site, fewer travel expenses for service teams, reduced downtime (some remote diagnostics and maintenance can be performed even while the robotic system is in operation), preventive actions (remote diagnostics can identify potential problems that will arise in the future), higher skilled personnel determine problems faster (as the service personnel uses the remote diagnostics system more and more systems are analyzed/fixed by the same persons, which leads to more experience and faster diagnosis for the future).

Future Directions

Integrating modern technologies which allow simultaneous usage of: chat, file transfer, internet audio and video conferences, will further expand remote diagnose and monitoring systems. Using these parallel communication channels the remote aid experience can be greatly improved, and thus the work can be carried out a lot faster.

Currently remote diagnostic and maintenance applications use additional sources for observing the system status (e.g. web camera). Future extensions could use virtual or augmented reality interfaces to further increase the experience, and allow more actions to be performed onsite.

Using remote operated service robots [**6**] additional hands on tasks can be performed. This would allow actions like: replacing consumables, refilling various liquids (e.g. anti-spatter liquid for torch cleaning), assisting in the case of collisions etc.

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Diagnoza de la distanță a sistemelor robotizate de sudare

Rezumat

Pachetele software analizate în prezentul articol servesc drept unealtă de diagnoză şi revizie de la distanță. Astfel devin posibile reducerea timpilor morți ai sistemului şi scăderea importantă a costurilor de service. Specialiştii în mentenanță asistă de la distanță la rezolvarea problemelor de service, indiferent de locația sistemelor robotizate.

Articolul analizează în continuare modalitățile de conectare de la distanță: fie printr-o conexiune directă prin internet la dulapul de comandă al sistemului robotizat, fie cu ajutorul unui calculator personal, conectat la rețeaua de comunicare comună a sistemelor robotizate. Sistemele informaționale analizate conțin toate funcțiunile de revizie şi diagnoză necesare pentru sistemele robotizate. Cu ajutorul unor funcții standardizate personalul de service poate astfel executa lucrări de diagnoză şi reparații de la distanță. Actualizarea versiunilor sistemelor de operare, controlul interfețelor, diagnoza stării sistemelor, reglaje ale acționărilor reprezintă doar câteva dintre opțiunile oferite de aceste sisteme , descrise în lucrarea prezentă.