Development of a control logic for Mixed-Reality-Robot mrShark

Considering up-to-date small batch productions tecniques

Hannes Eilers
University of Applied Sciences Kiel
24149 Kiel
Schleswig-Holstein, Germany
mail@hannes-eilers.de

ABSTRACT

The Mixed-Reality is a robot soccer league, using a half-virtual system for developing an artifical intelligence (AI) that's playing soccer. Already in use robots for the system aren't available any more, so a re-development was necessary. This paper summarizes the result from a bachelor thesis developing the control logic for a new Mixed-Reality-Robot. It includes a micro-controller driven control logic and consideres up-to-date small batch production techniques for choosing proper electronic components and electronic layout.

Keywords

Micro-Robot, Mixed-Reality, Control logic, Printed-Circuit-Board, Small batch production techniques

1. INTRODUCTION

The Mixed-Reality (MR) bases on a half-virtual robot system for developing AIs on a soccer scenario. For that small robots with dimension about $3cm^2$ [3], are driving on a screen with simulated soccer field and simulated soccer ball. One or multiple cameras are tracking the robots using marker codes on their top side. The tracked position is projected into the simulated soccer field, wich is used for an external agent program that can remote control the robot using an infrared transmitter system. The advantages of the system are a hardware-independent framework for AI programming and reduced hardware problems normally occuring with full reality robot-system, like orientation problems, autonomous working problems or limited on-robot resources[4].

Mixed-Reality robots used in the past where developed and manufactured by the CITIZEN company[2]. Currently CITIZEN is no more producing new robots and is not planning to do this in future. These orginal CITIZEN-Robots are titled as old bots and new developments are titled as new bots. Due to problems with unavailable components of the old robots and difficult maintance of the components, a re-development was necessary. That should consider long availability of components, easy maintance and cheap small batch production. Also compatibility of new systems with the old system are needed to enable easy changing to a new system. A bachelor thesis at the University of Applied Sciences Kiel worked on this and developed an electronic control circuit with printed-circuit-board (pcb) for a new bot called mrShark.

2. INDUSTRIAL PCB BATCH PRODUCTION TECHNIQUES

For re-development of a MR-Robot it was important to consider production techniques to select cost-efficient and highly available components as well as generating a proper producable pcb layout. In general industrial batch production of pcbs is divided into two steps, the production of the pcb itself and the assembly of the electronic components. For the first step the pcb layout mainly needs to consider dimension and spacings of circuit paths, where in the seconds step the electronic components playing a major role. They are influencing the costs for assembling the pcb because of higher programming costs of the assembly machine for a higher components diversity or using different assembling techniques as surface mounted devices (SMD) [5] and thorugh hole technology (THT) [6]. Also placeing only a few components on one side (layer) of the pcb is inefficient due to extra costs for programming the assembly machine for assembling the second side. The total number of components is also important due to limitations of the maximum capacity of components storage at one assembly machine. All this needs to be considered while choosing an electronic component [1].

3. REQUIREMENTS FOR MRSHARK

From the problems of the old bots and the techniques applied during industrial batch production the following requirements are arising [1]:

- Cheap production
- Highly available electronic components/devices
- Simple programming

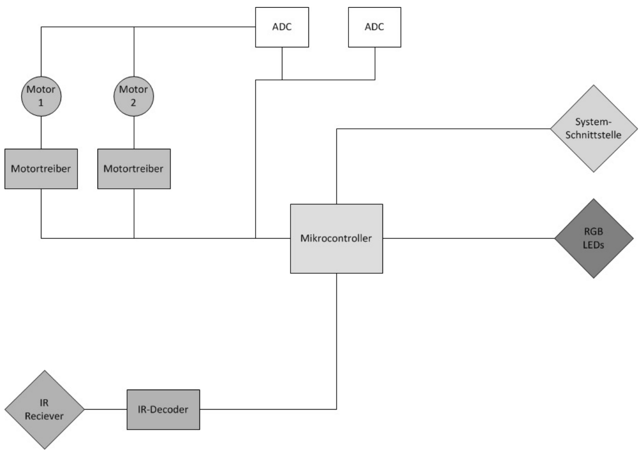

Figure 1: Mixed-Reality robot mrShark electronic circuit concept.

- Simple extending
- Long runtime
- Autonomous power supply
- Compatibility with existing system
- Measurement of relevant system voltages and currents
- Optimization in view of industrial small batch productions

3.1 Limitations

Due to backward compatibility the new system has some limitations as following [1]:

- PCB dimension max. 31,0x26,0mm (right angle) with 45 degree phase on all four edges
- Using 2 GM15 dc motors
- Remote control via 115,2kBit/s infrared signal

4. CONTROL LOGIC

The control logic of the mrShark robot is used to recieve remote infrared data, to control the robots motors and to show it's current state. The control logic is explained in details below.

5. CONCEPT

The concept of realising a electronic ciruit was a mircocontroller based solution with some external integrated circuits (IC) (see figure 1) for controlling the motor voltage and current as well as an infrared to serial decoder for decoding remote infrared data and some integrated analog to digital converters (ADC) for mesearuring the relevant voltage. Rgb leds are used to light up the robots case and to show it's current state. Finally an interface should be used to extend the system with additional electronics.

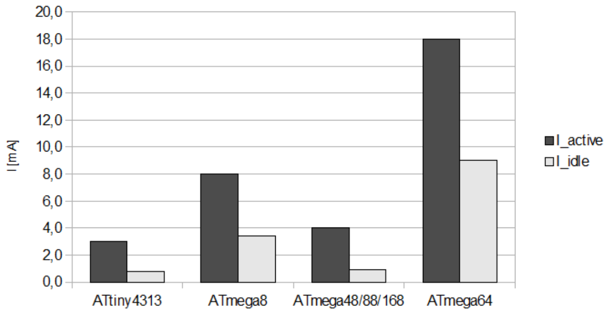

Figure 2: Supply current [mA] of different AVR microcontroler devices in active and idle state.

5.1 Power supply

The power supply should be able to enable a long autonomous runtime without recharging. For that two lithium-polymer (LiPo) rechargable batteries are used in parrellel mode. With that the supply voltage ist between 4.1V and 3.3V[1]. The rechargable LiPo-batteries offering a long runtime without any need to replace them. They have also small dimensions and enabling a high capacity in parallel mode.

5.2 System interface

The system interface uses a pin-header in the middle of the robot's pcb to prodive internal voltages (like battery voltages) and communication data for external electronics that could get mounted above the control logic's pcb.

5.3 Components

As central processing unit an AVR ATmega168 microntroler with 16MB program flash is used. The microntroler provides enough computing power and program data ram for analysing incoming remote data streams and measured data. On the other hand the device integrades often used peripherals with a minimum of power consumption (see figure 2). The ATmega168 can get replaced with the ATmega48 or ATmega88 devices with 4MB and 8MB program flash. These optional devices are cheaper but offer less program memory.

The mrShark control logic also includes an infrared to serial decoder and two motor drivers, two Twisted-Wire-Interface-Bus (TWI-Bus) ADC are used, as well as an TWI-Bus Switch to switch between internal and external TWI master devices in case of using many robots connected together.

The control logic uses a status led and four rgb-leds to illuminate the robot's case and for providing visual information about the robot's state.

6. EVALUATION

The electronic components used and the layout of the control logics pcb are selected to provide a product life-cycle as long as possible, as well as small batch production costs. For that the worldwide availability of components, the diversity of component types used and the layout arrangement of components at the pcb are evaluated. Not rated are state of the art components like often used resistors and capacitors,

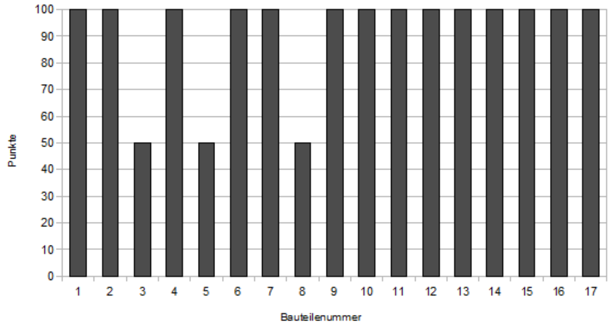

Figure 3: Evaluation points for most important control logic components (by number).

because often they are in-stock products of pcb production companies. The evaluation uses point in range of 0 to 100 to rate every evaluation item on a fictive production of 150 pcbs [1].

For the component availibility the products available at the worldwide distrubutor Farnell was analysed at august 2013. For that the needed number of components n and the available number of components k were used. A multiplicator m indicates the art of availibilty (see equation 1). For components in Farnell's EU stock m is 1.0, for components only available in Farnell's US stock it is 0.75, if components are only available from other distrubutor it is 0.5, for components only available from producer it is 0.25 and 0.0 for unavailable products[1].

$$P_1 = \frac{k}{n} * m * 100\text{points} \tag{1}$$

For the 17 most important components, an average 91 of 100 points is reached. Two components are only available from other distributors than Farnell and one component has the be ordered directly from producer (see figure 3).

For component diversity a quotient of different component types v and total number of components n is used (see equation 2). So less diversity is rated bettern in case of lower machine programming costs during production.

$$P_2 = (1 - \frac{v}{n}) * 100\text{points} \tag{2}$$

For 26 different and total 66 components the mrShark control logic pcb reaches an average 61 of 100 points [1].

For the evaluation of the pcb's layout the number of components on each side of the 2-layer pcb, as well as the number of different orientations are used (see equation 3). Where n_{MINOR} is the number of components on the pcb side with the least number of these components and n_{MAJOR} the number of components on the other side. The multiplicator m is 1.0 if all components of one type having the same orientation. For every additional orientation it is decreased by 0.25.

$$P_3 = \frac{n_{MINOR}}{n_{MAJOR}} * m * 100\text{points} \tag{3}$$

The average number of points of the pcb's components layout is 87 of 100 points, where 5 from total 26 component types have two different orientations and 3 component types have more than two different orientations [1].

The average of all three evaluation aspects, availibilty (P_1), diversity (P_2) and layout (P_3) is 80 of 100 points (see equation 4) [1].

$$P = \frac{P_1 + P_2 + P_3}{300\text{points}} * 100\text{points} \tag{4}$$

7. CONCLUSION

The developed control logic for the new Mixed-Reality robot mrShark offers control of two DC-motors via infrared interface. The choosen micocontroller AVR ATmega168 provides enough computing power and memory storage for complex programs. The additional periphery offers possibilities to control different volatges and a system interface provides the possibility to extend the system with additional electronic circuits. The selected components used for the pcb and their layout on the pcb are analysed and evaluated for small batch productions with an overall good result. With these features the mrShark can be used as replacement system for old Mixed-Relaity robots.

8. REFERENCES

[1] H. Eilers. Entwicklung der Steuerelektronik eines Mixed-Reality Roboters unter Beachtung aktueller Fertigungstechniken industrieller Kleinserien. Bachelor thesis, University of Applied Sciences Kiel, August 2013.

[2] R. Lions. FAQ zur Mixed-Reality. tec.reutlingen-university.de/robocup/mixed-reality/faq.html, August 2013.

[3] NorthernStars. Mixed-Reality Roboter mrShark. northernstars-wiki.wikidot.com/projects:mrshark, December 2014.

[4] NorthernStars. Mixed-Reality System. northernstars-wiki.wikidot.com/robocup:mrsystem, December 2014.

[5] R. Sautter. *Leiterplatten mit oberflächenmontierten Bauelementen.* Voegl Buchverlag, 1st edition, 1988.

[6] W. Scheel. *Baugruppentechnologie der Elektronik.* Verlag Technik, 1997.