

EUROBOT^{open} 2011

Chess'Up!

Pilot Study RRT

Austria

“Chessy”



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2. GENERAL DESCRIPTION

2.1 THE ROBOT

The robot was constructed in the drawing program CATIA V5R18. The main objective in the design of the robot was to develop the chassis with a lightweight construction based on the application of CFK plates (carbon fiber reinforced plastic) and aluminum plates.

The robot dimensions are:

Starting configuration	1165mm
Deployed configuration	1395mm
Height	350mm

The robot collects the king, queen and pawn with the grasping system. The main task of the robot is to collect the elements and place them onto the own fields.

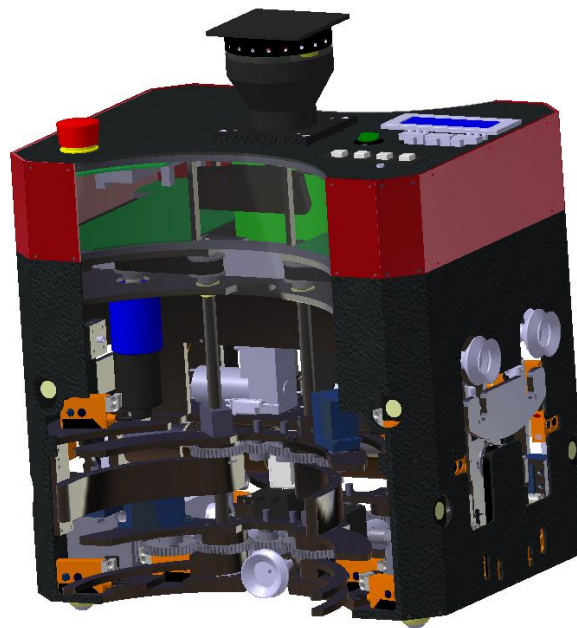


Fig. 2.1 The robot

2.2 SIMPLE OUTLINE OF THE ROBOT

The robot is divided into different zones. At the front and back are two grasping systems to handle kings, queens (royals) and pawns. At both sides of the robot there are two arms to deal with pawns. The robot can store up to eight playing elements.

The robot has 28 infrared sensors and eight ultrasonic sensors to locate the opponent robot and to detect and to distinguish between royals and pawns. The control unit is a single control board, which is supplied with 28.5V. The opponent robot detection system, the programming interface, the LCD and the emergency stop switch are located on top of the robot. Figures 2.2 and 2.3 show the robot in a top view and a side view.

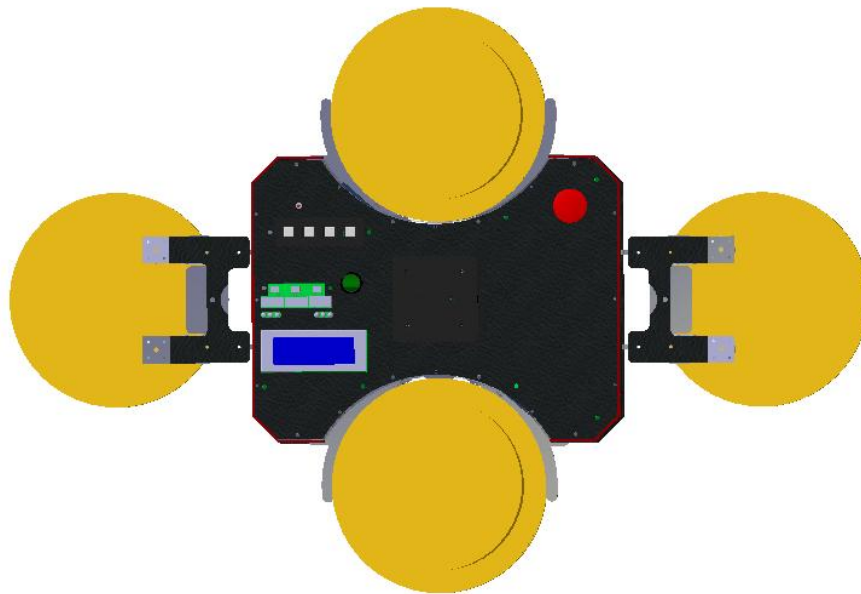


Fig. 2.2 The robot – top view

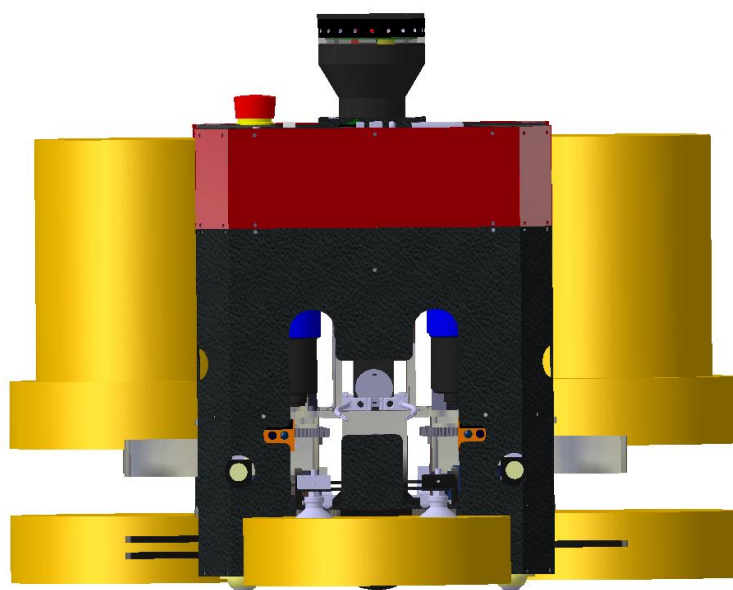


Fig. 2.3 The robot with chassis - side view

3. TECHNICAL DESCRIPTION

3.1 ROBOT MOVEMENT

The drive mechanism is in the base of the chassis and is equipped with a differential drive. Two DC-motors with a planetary gear are used to move the robot. The drive motors also contain a gearbox with a gear transmission ratio of 14:1 and a magnetic encoder for the speed and positioning control (shown in Fig. 3.1).

A special controller at the main board is implemented to guarantee the exact execution of the movement.

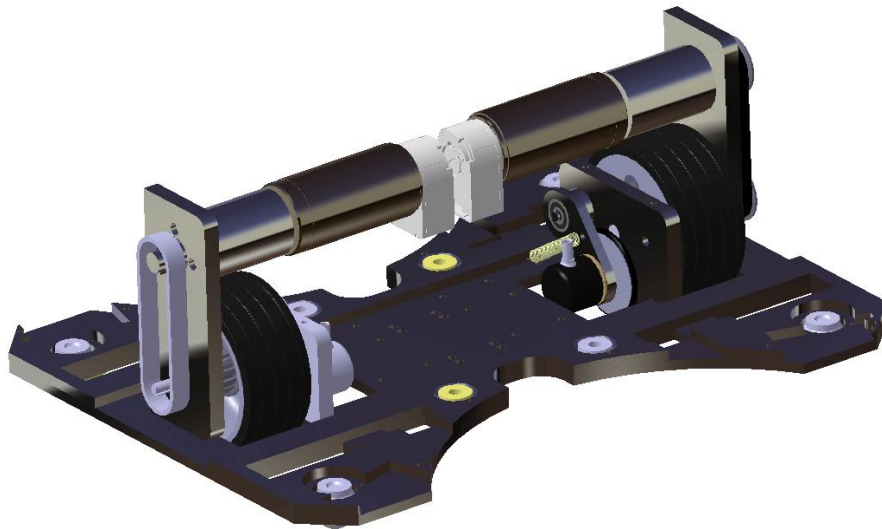


Fig. 3.1 Motion Control Unit

Calculation of the acceleration by a given torque:

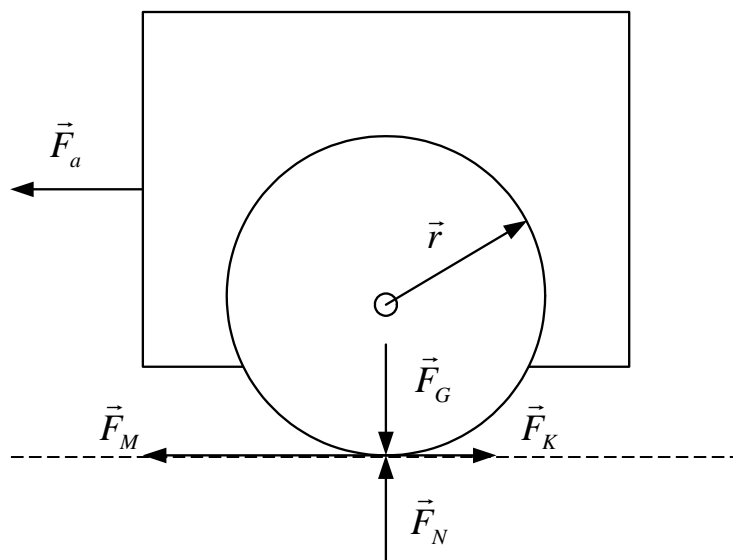


Fig. 3.2 Modeling of the occurring forces

Symbol	Description
r	radius
F _G	weight
F _N	normal force
F _K	lose of force by rolling friction
F _M	driving force
F _a	acceleration force
M	motor torque
g	acceleration of gravity
μ _k	friction coefficient
m	mass of the robot
m'	mass per motor
P	motor power
n	rotation per minutes
f	rotation per seconds
v _{End}	final velocity
U	wheel circumference
ω	angular velocity
a	acceleration of the robot

$$\vec{M} = \vec{r} \times \vec{F}_M ; |\vec{M}| = |\vec{r}| \cdot |\vec{F}_M| \cdot \sin \varphi \Rightarrow |\vec{F}_M| = \frac{|\vec{M}|}{|\vec{r}| \cdot \sin \varphi} \quad (3.1)$$

$$M = \frac{P}{\omega} \quad (3.2)$$

$$\omega = 2 \cdot \pi \cdot f \quad (3.3)$$

$$f = \frac{n}{60} \quad (3.4)$$

$$v_{End} = f \cdot U = \frac{n \cdot U}{60} = \frac{n \cdot 2 \cdot \pi \cdot r}{60} \quad (3.5)$$

$$\vec{F}_K = \vec{F}_N \cdot \mu_K = m' \cdot \vec{g} \cdot \mu_K \quad (3.6)$$

$$\begin{aligned} \vec{F}_a &= \vec{F}_M - \vec{F}_K \\ F_a &= \frac{M}{r} - m' \cdot g \cdot \mu_K \\ a &= \frac{M}{r \cdot m'} - g \cdot \mu_K \end{aligned} \quad (3.7)$$

$$a = \frac{60 \cdot P}{r \cdot m' \cdot 2 \cdot \pi \cdot n} - g \cdot \mu_K = \frac{60 \cdot P}{U \cdot m' \cdot n} - g \cdot \mu_K \quad (3.8)$$

$$a = \frac{P}{m' \cdot v_{End}} - g \cdot \mu_K$$

Excel-Calculation:

M [Nm]	r [m]	μ_K	gearbox	motors	n [U/min]	m [kg]	a [m/s ²]	v _{End} [m/s]
0,0933	0,037	0,025	14	2	6910	10	6,82	1,91

3.2 ELECTRONIC AND POWER SUPPLY

The power supply of the robot consists of two NiMH accumulators. These accumulators are connected to the supply-board. There are 3.3V, 5V (logic), two 5.5V (power), 12V and 24V TRACO voltage converter. This board is connected to the main control board. There are three Xmega 256 microcontrollers from Atmel. The Xmegas check the sensors, control six DC-Motors and eight brushless servos. A LCD module is also connected to the main board.

Technical data of the accumulator:

accumulator technology	NiMh
maximum output current	30A
maximum loading current	4.2A
Capacity	4200mAh
dimension (l x w x h)	218 x 45 x 22 mm
Weight	787g
Voltage	12V

3.3 ELEMENT MANAGEMENT SYSTEM

At the front and at the back of the robot are two grasping systems to collect the royals and pawns (see Fig. 3.5). At each side of the robot are two arms to collect pawns. On each arm is a vacuum grasping system with an individual vacuum pump so that each arm can operate independently from the other. The elements are stored at the grasping system. That way the robot can transport a maximum of six pawns and two royals at the grasping system (see Fig. 3.3).

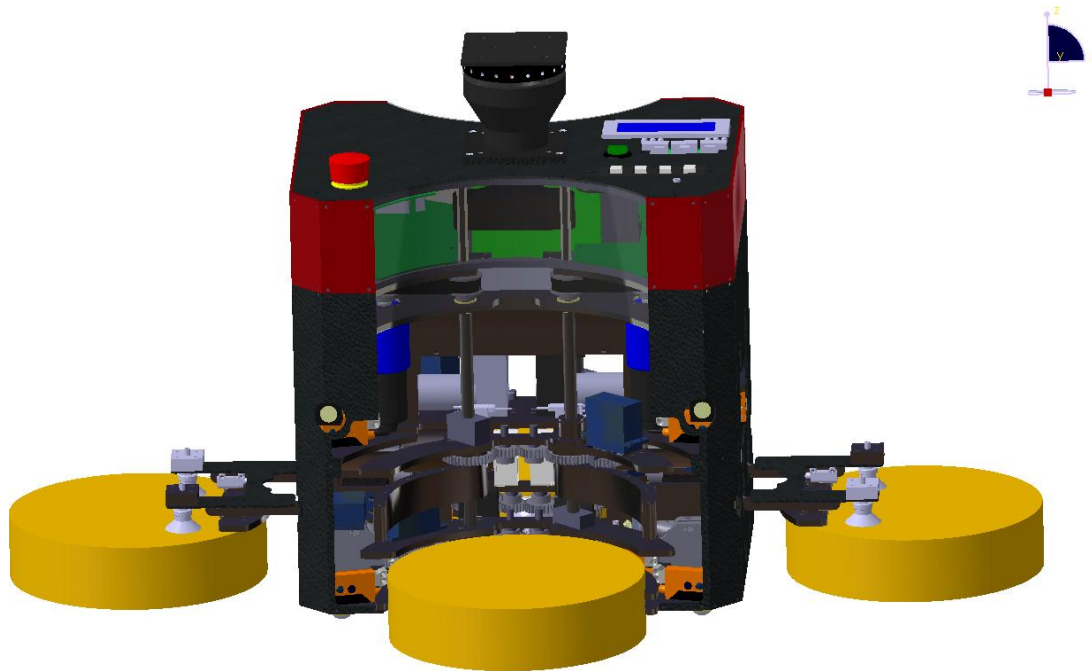


Fig. 3.3 Front view – handling the pawns

The bottom of the robot is made of a 5mm aluminum plate. Four rollers and the drive system are mounted on this plate (see Fig. 3.4).

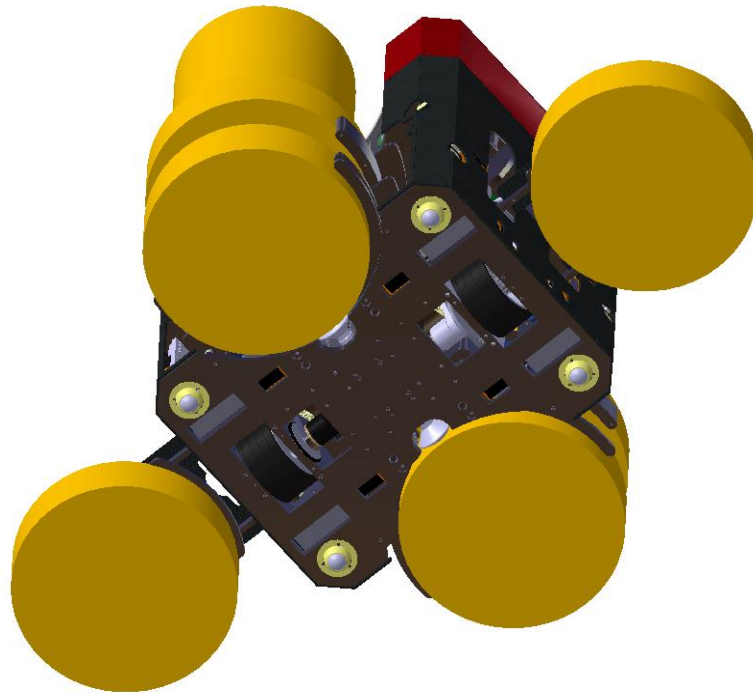


Fig. 3.4 Bottom view – sliding unit

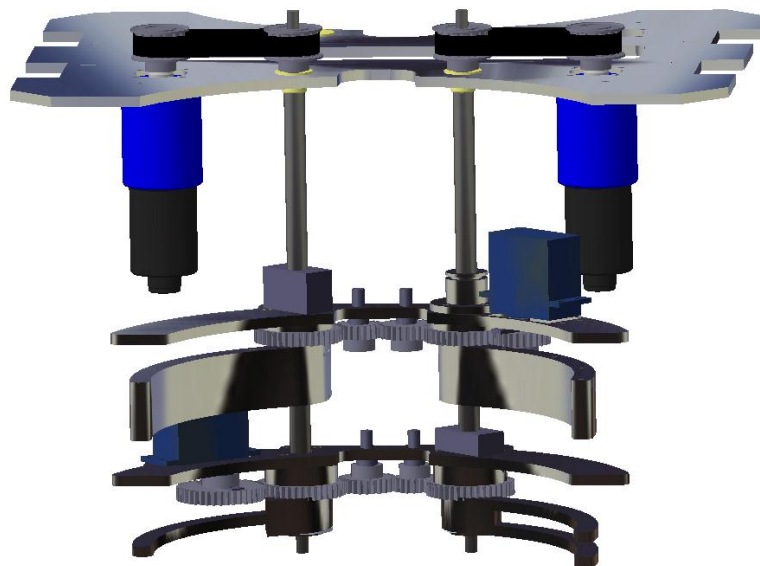


Fig. 3.5 Grasping System

3.4 POSITION DETECTION

3.4.1 Odometric Navigation

The basic navigation is based on odometric navigation. As shown in Fig. 3.6 the robot will measure the increments of the left and the right wheel cyclically and calculate the differential path ds and the angle φ_R . With these variables the exact x- and y-position can be calculated.

At the beginning the x and y coordinates and the starting angle must be known and these values are stored in the microcontroller.

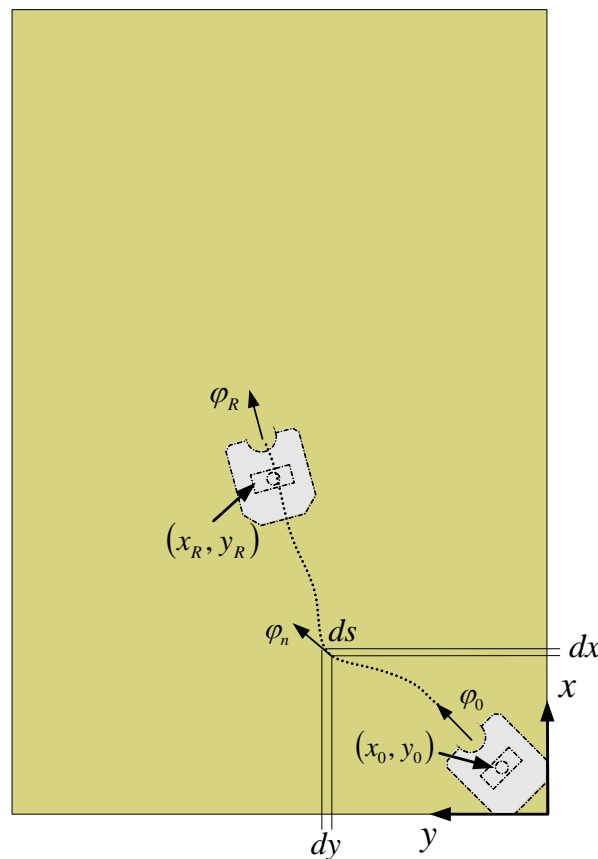


Fig. 3.6 Odometric navigation

$$s_n = \frac{1}{2} \cdot (\text{Increments_Left} + \text{Increments_Right}) \quad (3.9)$$

$$\varphi_R = \varphi_0 + (\text{Increments_Right} - \text{Increments_Left}) \quad (3.10)$$

$$ds = s_n - s_{n-1} \quad (3.11)$$

$$x_R = x_{R-1} + ds \cdot \cos \varphi_R \quad (3.12)$$

$$y_R = y_{R-1} + ds \cdot \sin \varphi_R \quad (3.13)$$

3.5 AVOIDANCE SYSTEM

Eight ultrasonic sensors are located around the robot and are required for the obstacle avoidance system. The sensors have a maximum operating distance of 100 cm. That way the robot can detect obstacles within a perimeter of over 2 m.

On top of the robot there is an opponent robot detection unit. This unit detects the direction in which the opponent robot is located.

Due to this fact the robot can detect the position of the opposing robot at any time and it is always in a position to avoid a collision. The robot tries to create a profile of the opposing robots' movement so that it is able to calculate the best way to go around it (as shown in Fig. 3.7).

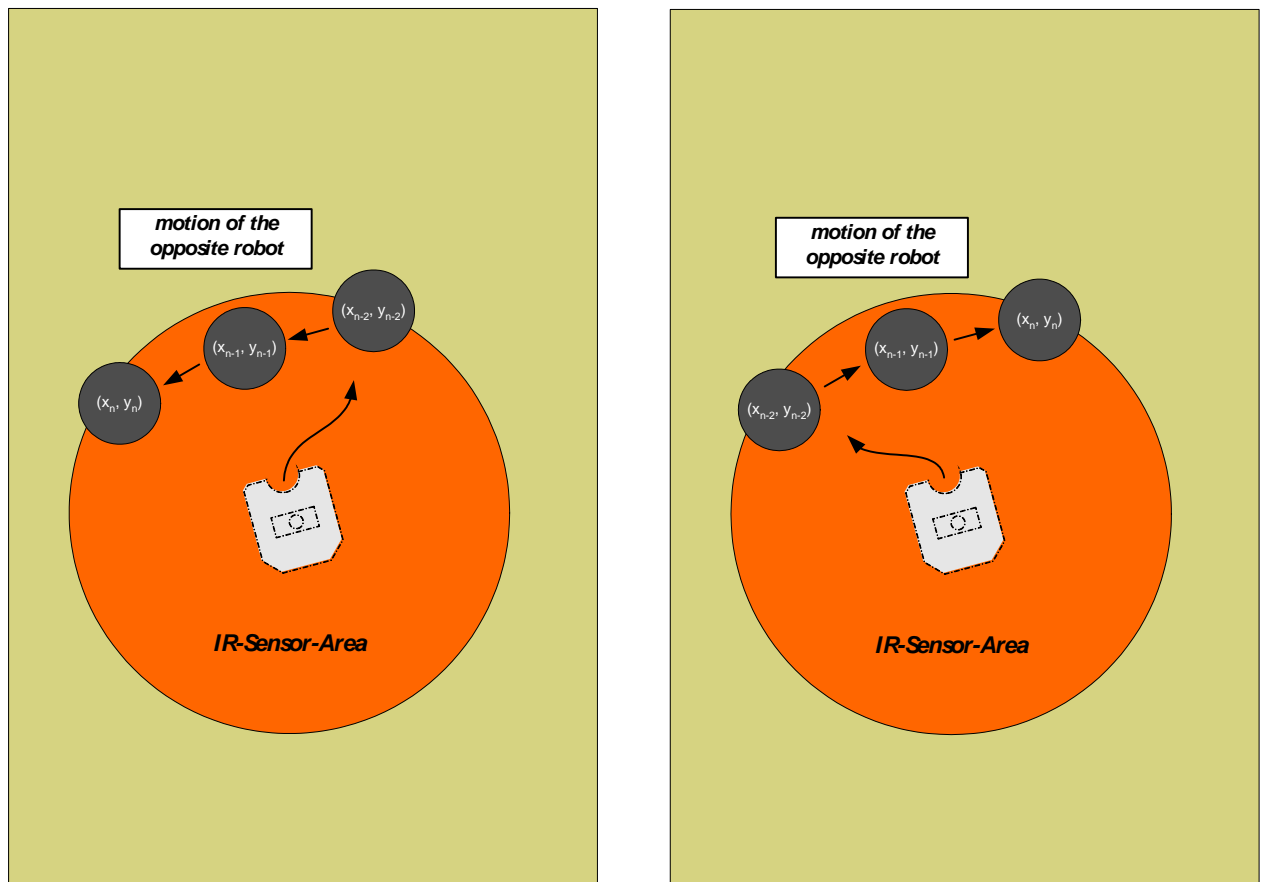


Fig. 3.7 The robots' path finding

3.6 DETECTION OF THE PLAYING ELEMENTS

To plan an optimal route for the robot, there are two cameras which detect the playing elements. The cameras act as colour sensor and detect the mean colour of a predefined position. Fig. 3.8 shows the close range of the front camera. The classification of this section allows the determination of all royals and pawns. The information is transferred via serial interface to the main control board.

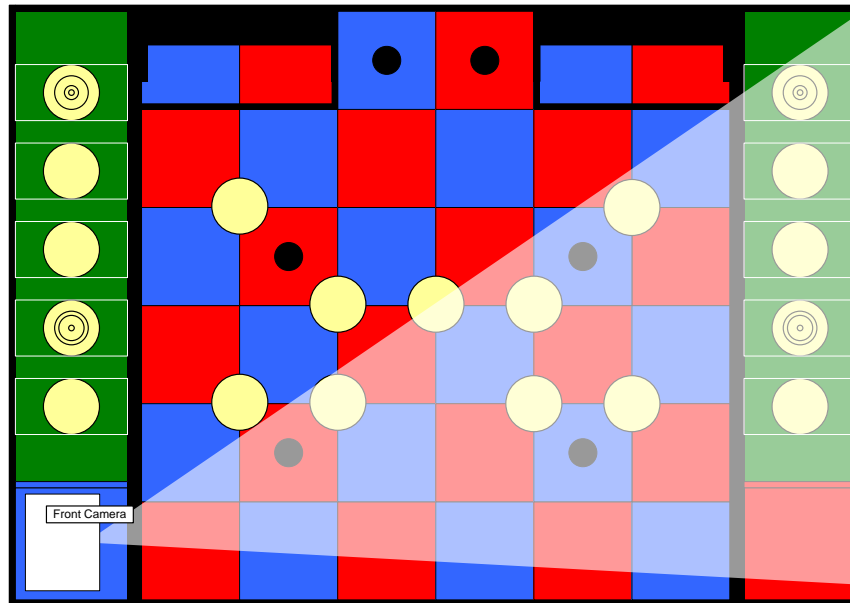


Fig. 3.8 Close range of the cameras

Fig 3.9 shows the applied camera module C910 from the Logitech.



Fig. 3.9 Applied camera module Logitech C910

3.7 OPPONENT ROBOT DETECTION UNIT

On top of the enemy robot there is a sending module, and on the top of our robot there is the interacting receiving module and both together build the opponent robot detection unit. The device detects the direction in which the opponent robot is located and also the bearing can be determined. Additionally the robots own location is determined by analysis the measurement results.

Due to this fact the robot can detect the position of the opposing robot at any time and it is always in a position to avoid a collision. The robot tries to create a profile of the opposing robots' movement so that it is able to calculate the best way to go around it. (The opponent robot detection unit and the measurement parameters are shown in Fig. 3.10).

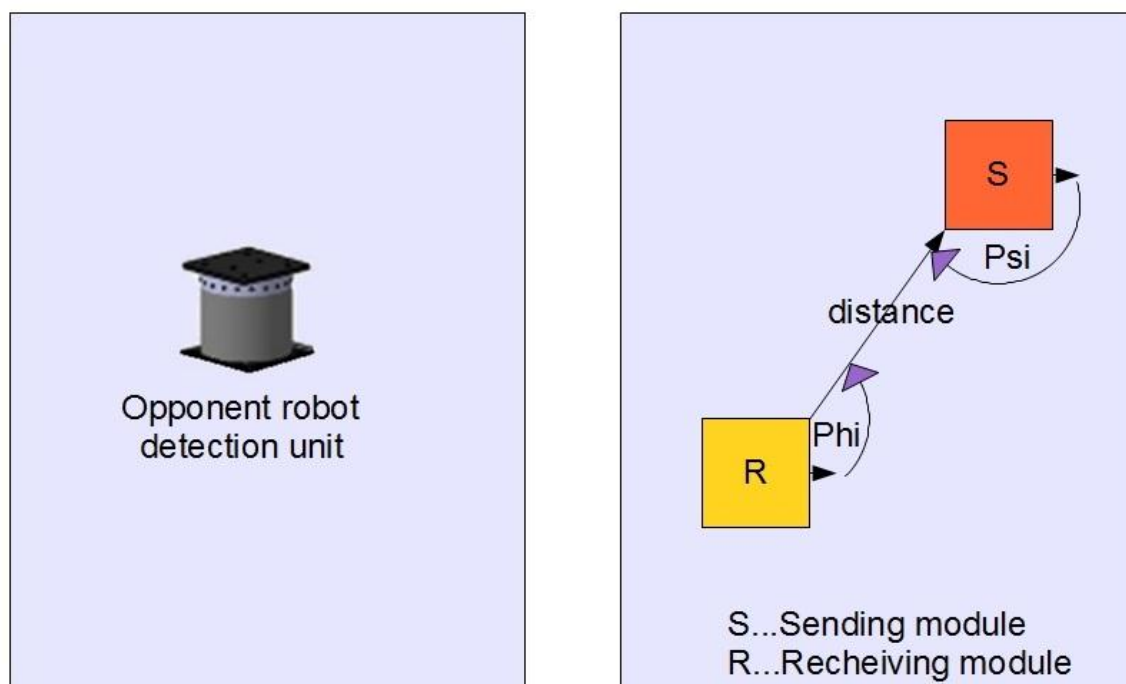


Fig. 3.10 The opponent robot detection unit

Technical data of the opponent robot detection unit:

dimension (l x w x h)	80 x 80 x 80 mm
accuracy of angle measurement	9°
accuracy of distance measurement	500 mm
operating distance	up to 1800 mm

3.10 ROBOT INTELLIGENCE

3.10.1 Electronic System

Control System:

The main processor distributes the tasks to the slave processors. It is the central unit which communicates with the slaves via the serial interface (RS422). The main processor executes the main program which includes all the strategies, the timing, the route planning, etc.

The slave processors can control three DC motors and four servos. It controls the speed, the position and the odometric navigation system.

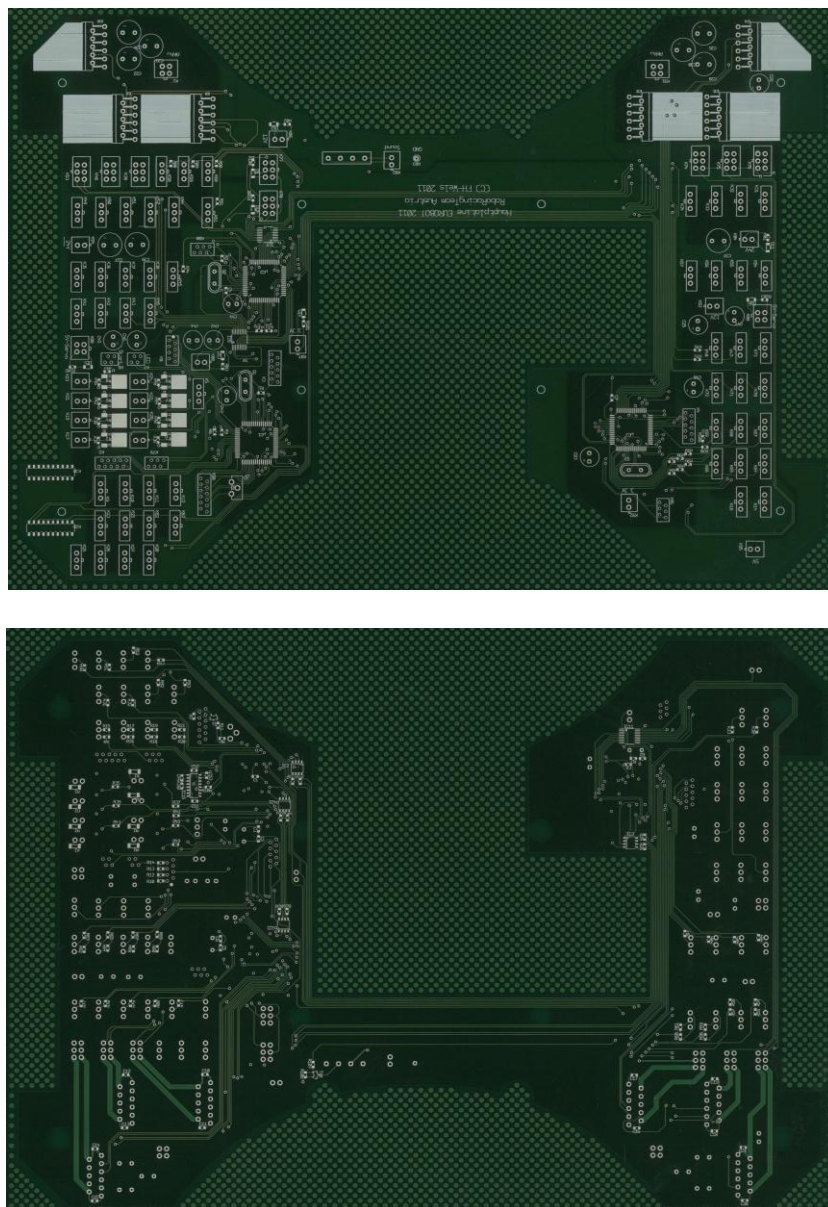


Fig. 3.11 Main Control Board

Power Supply:

The power board supplies the robot with all needed voltages. It provides 3.3V/1200mA (processors), 5V/3000mA (LCD), 5.5V/24A (digital servos), 12V/5000mA (sensors - ifm) and 24V/2080mA (sensors - Baumer).

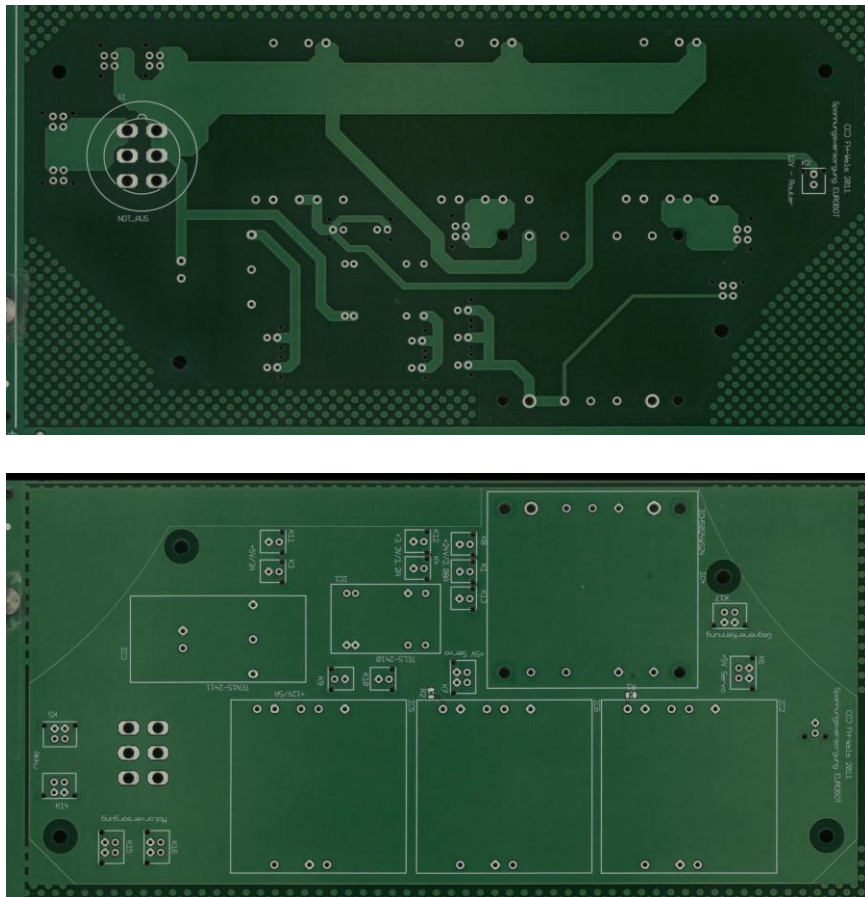


Fig. 3.12 Power Supply Board

Interface:

On this board are the LCD module and the programming interfaces. Also are there LEDs to visualize the actual playing colour.

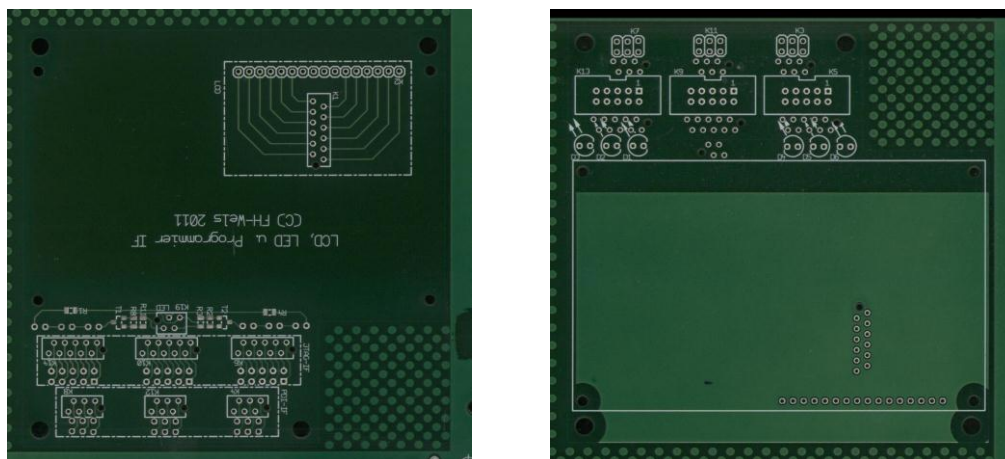


Fig. 3.13 Interface Board

3.10.2 Software






All software is programmed with the programming tool CodeVisionAVR and is written in C.



The main board runs a self-developed cooperative multitasking system, so that more actions can be carried out at the same time.

4. ORGANISATION

4.1 MEMBERS' SKILLS

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	<p>Dzulaidin Tasrin Nurain E-Mail: Nurain.DzulaidinTasrin@students.fh-wels.at Skills</p> <ul style="list-style-type: none"> • Mechanic
	<p>Ing. Michael Zauner BSc Tel.: +43 (0)7242/72811-3520 E-Mail: michael.zauner@fh-wels.at Skills</p> <ul style="list-style-type: none"> • Team leader • Electronic • Programming

4.2 PROJECT SCHEDULE

<i>October</i>	<ul style="list-style-type: none"> • built the EUROBOT-table • to construct the mechanic components of the robot • testing of the new driving system • testing of the obstacle avoidance
<i>November</i>	<ul style="list-style-type: none"> • to construct the mechanic components of the robot • testing of the new driving system • testing of the opponent robot detection
<i>December</i>	<ul style="list-style-type: none"> • to assembly the robot completely • to wire up the electronic
<i>January</i>	<ul style="list-style-type: none"> • to assembly the robot completely • to wire up the electronic
<i>February</i>	<ul style="list-style-type: none"> • to start running all components
<i>March</i>	<ul style="list-style-type: none"> • to develop different strategies
<i>April</i>	<ul style="list-style-type: none"> • to develop different strategies
<i>May</i>	<ul style="list-style-type: none"> • at the early May → AUSTROBOT • to improve the performance of the robot • from 19st. May to 21th May → SWISS-EUROBOT

4.3 PARTNERSHIP

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	<p><i>Supplier Sensors</i></p> <p>ifm electronic gmbh Wienerbergstr. 41 (Gebäude E) A-1120 Wien, Austria www.ifm-electronic.com</p>
	<p><i>Supplier Polymer Gears and Bearings</i></p> <p>igus polymer Innovationen GmbH (OÖ) Ort 55 A-4843 Ampflwang, Austria www.igus.at</p>
	<p><i>Creation of the CFC plates</i></p> <p>Filiale Wels Land Zoblstr. 11 a A-4650 Edt/Lambach Tel.: +43 7245 20661 Fax: +43 7245 20661 40 Tel.: 0800 288 288</p>
	<p><i>Grasping System</i></p> <p>SMC Pneumatik GmbH (Austria) Girakstr. 8 A-2100 Korneuburg Tel.: +43 2262 62280 0 Fax: +43 2262 62285</p>