5dpo Robotic Soccer Team for Year 2003

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Abstract. The 5dpo team is currently building new omni-directional robots. The new robots have controlled force Electro Magnetic passing/kicking mechanism as well as a roller device. The vision system has been ported to Linux in order to reduce system lag and eliminate previous issues of control degradations caused by non-synchronisation of frames. Team strategy is based on hierarchical state diagram engine. A dynamics prediction layer for enhanced motion control allows for enhanced overall performance of the team.

Global Robot Design

The 5dpo Team is currently building new Robots based on omnidirectional wheels. This work is in an advanced state but full assembly is not mature yet. It is very likely that the new robots will be ready by the time of the Padua 2003 RoboCup competition but if it is not, last year's robots will be used. This article briefly describes both models: last year's "wheel chair" design and new omni-directional design.

The last year's robots are the ones used in Seattle 2001 and German Open 2002. The robots have a "wheel chair" configuration: they are fitted with two differential wheels. Stepper motors drive each wheel independently. There is no third wheel and a pair of pods sustains the robot. A castor would result in a more complex mechanical design as well as an increased uncertainty in its dynamical model. The walls of the robots are made from transparent acrylic. The kicker is made of spinning bars that are accelerated to high speed. An articulated "bumper" also allows for protection of adversary robots.

The new project uses 3 omni-directional wheels each powered by a DC motor with direct coupling to a gearbox. A freeware 3D cad tool called PTC ProDestktop was used to develop the new prototype and rendered image of the robot project is seen in figure 1. The fitted gearbox provides a reduction factor of 1:19. A fully new Electro-Magnetic kicker is now used. A roller device is also under intensive study. This device would allow for improved game-play as it allows the control of the kicking strength.

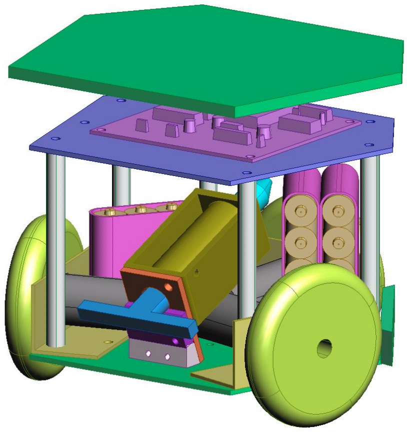

Fig. 1. Rendered image of the project for the new omni directional robot; omni directional wheels are shown as solid and are not detailed

Electronics and Communications

The 2002 version of the robots uses 12 V of Ni-Cd batteries for power. The motors were driven by two H-bridges while all digital circuitry gets its power from a switching regulator. The controller for the motors is an 8-bit RISC microcontroller (Atmel AVR90S8515).

The new prototype uses Ni-MH batteries. A low drop regulator from 6 Volts is used to drive digital circuits. All other parts of the robot now use the full 18 V. The new prototype also features an electromagnetic kicker. Energy from the batteries is transferred to capacitors while the voltage is multiplied in order to strengthen the kick. Carefully controlling kicking times allows for controlled passing/kicking strength.

The wheel chair design uses a second Atmel AVR90S2313 that handles all real time communications. There are two small single frequency Radio Frequency (RF) modules (433 MHz and 418MHz). An additional communication channel is provided through an InfraRed (IR) link. We successfully used the IRDA HSDL-1001 chips to communicate with the robots in spite of the heavy lighting conditions. The emitting LED's are at the camera level, pointing down. On the receiving side an automatic gain controller and adequate filtering are necessary to get reliability. The HSDL-7001 chip is used to perform Encoding/Decoding. Alignment problems and also power concerns led to having 3 emitting nests of a total of 8 LED's HSDL-4220. These LED's were submitted to bursts of 1.6 microsecond under a current of 0.5 Amps. The information transmitted via IR and RF is the same.

The new design of robots uses two Atmel ATMega8 for the same purposes as the previous version.

Robot Software

Embedded software for both microcontrollers was already totally written in C language. The C code is compiled with the libre AVR-GCC program. This allows a high level of code understandability and maintainability. The software architecture is basically the same so the code was ported to the new microcontrollers without much effort. There are 2 communication channels: RF and IR. Special packets allow for remote robot configuration such as robot number, future receiving frequency, etc. The robot has no autonomy and executes simple commands like set speed of motors, kick, etc.

Vision and Control

The vision system is based on two general consumer PAL cameras, one for each mid-field. A new Linux Vision Server is now used. It allows for the two vision boards to work in the same computer and for the frames to be synchronised. Vision boards are based on the BT878 chip. The previous version of the image processing software was written in Delphi for Windows and now has been ported to Kylix under Linux. A certain degree of portability is possible between these compilers so porting was not hard. The Vision Server communicates with the Strategy Server via sockets over an Ethernet 100 Mb/s network.

The vision software first prepares the image by using a special filter designed to circumvent image degradation caused by the PAL coding and transmission scheme of the image. A fuzzy system is then used to classify the colour of each pixel and aggregates them in contiguous groups. The observed groups are matched and that information is incorporated in the state resorting to a set of Kalman filters tuned to the dynamics of each kind of object. The Strategy Application uses the global system state as well as strategy rules to generate motor orders and send them to the players. The Strategy Application is based on a hierarchical state diagram engine. Each robot has a Role that may select a Task that, in turn, may select different Actions. Of course, details of the strategy are very different for omni-directional robots and for “wheel chair” robots.

Global team tactics are quite stable. The defence robots stand in alignment in such a way that the robot that holds the ball can't easily shoot for goal. Team behaviour is based on robots changing roles on certain conditions. Certain robot roles have priority over others and thus co-operation is based on well-defined priorities. This prevents robots from the same team from harassing each other.

The control loop is closed through the cameras, as seen in Figure 2. It must be stressed that while the "sampling" frequency of this loop is 25 Hz, there is some intrinsic lag that degrades its optimal performance. Implementation details of the Linux vision server also decrease intrinsic lag. The PAL signal takes 20 ms to deliver each interlaced frame, then some time is spent processing it and then the decision is made about the new course of action. There is also the time spent sending the orders over the RF/IR channels to the robots. System overall performance benefits from a prediction layer where low level control is calculated taking into consideration known system lag.

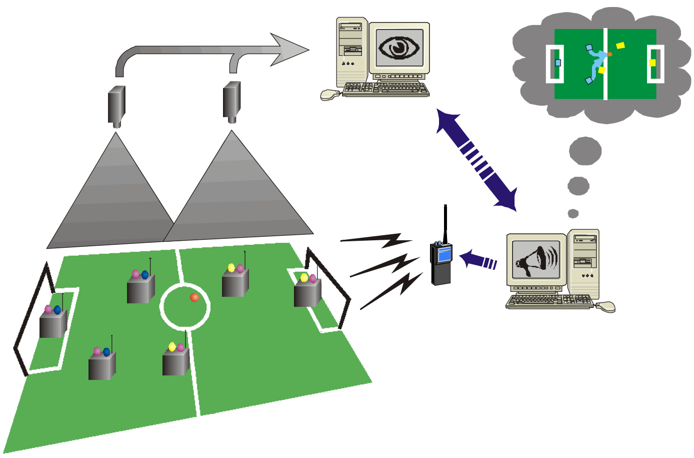

Fig. 2. Diagram of the closed loop workings of the team

Both previous and current robot's designs use a round-shaped bar code to keep track of which robot is which (as in Figures 3 and 4). Around the circular colour of the team (yellow or blue) there is room for 6 bits of black or white sectors of 60 degrees. As only 5 robots are needed on the field at the same time, from all the possible 6 bit combinations, the chosen combinations were those that had the maximum transitions and those that are not a rotation of previously chosen codes (Figure 4). From this bar code we retrieve a binary code of a robot as well as its orientation. Orientation noise is less then 4 degrees for our system.

Fig. 3. Human and robot team also showing robot's bar codes at German Open 2002 (5dpo robots on the right side of the picture, with blue team colour)

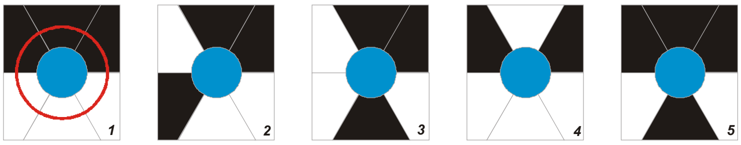

Fig. 4. Bar codes for the blue team and a sample scan circle on number 1 (shown in red)

Final Remarks

The 5dpo team has new omni-directional robots that show promising features. The complete project is not quite mature so the new robots will play only if their features are fully tested. The new project uses an Electro-Magnetic passing/kicking device that allows controlling the force applied to the ball.

The vision system has been ported to Linux. A single PC now runs the new Vision Server. It has 2 vision boards for the 2 cameras, one for each mid-field. The frames are now synchronised and several control degradations were removed. The closed loop lag also has been reduced.

The bar code on top of the robots allows for good robot tracking and angle measurement.