Persia 2003 Team Description

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Abstract:
In this paper we are going to give a general description of second generation robots of Persia Middle Size League (MSL) team for RoboCup 2003 contests held in Italy. We have tried to focus on description of areas such as omni directional mechanisms, mechanical structure, optimized odometry system, cooperative behavior and world modeling. Persia team got the third place in RoboCup championships 2003.

Introduction:

Persia RoboCup team formed since 2001 and participated in Middle Size League RoboCup 2002 held in Fukuoka-Japan. Persia is currently working in the robotics laboratory in Isfahan University of Technology (http://robocup.iut.ac.ir/).

The new generation of middle size robot is fully omni directional with omni-vision system, omni navigation system and omni-kick mechanisms. We believe that a reliable mechanical structure design, robust algorithms and sensor fusion are principals of a team play in MSL. In the following an overall description of the team, focusing on the most significant research issues is presented.

Fully Omni Directional Robot:

The idea of an omni directional robot is not new in RoboCup, but constructing a fully omni directional robot can be very useful in extended behavioral capabilities and visual information, thus Persia's new generation of robots are equipped with omni navigation system, omni kick mechanisms and omni vision system.

This combination brings the idea of a robot with no head direction into existence. Such a robot can respond more quickly and it would be capable for more sophisticated behaviors such as ball passing or goal keeping. Persia successfully demonstrated its passing behavior with two robots continuously passing the ball toward each other. In fact the most beneficial feature of the omni kick/omni navigation soccer player robot is the capability of regaining and shooting the lost ball with no extra time needed for directional robots to align their head in the desired direction.

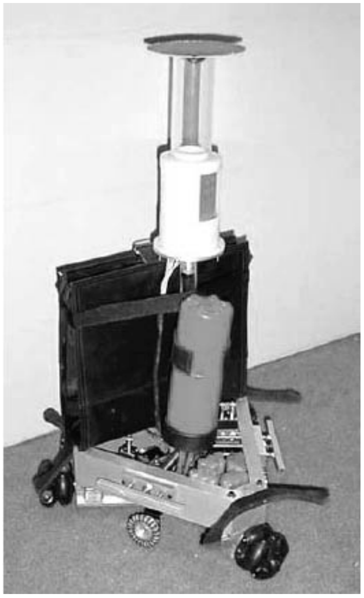

Fig. 1. : The picture shows the robot structure with omni directional wheels for driving and odometry sensors.

The mechanical platform is completely designed, simulated and manufactured using CAD/CAM methods. Parameters like mechanical consolidation, material weight and compact design were mostly considered in robot design procedure, which led to a firm and reliable structure which hosts other parts of the robot to be assembled on it.

Mechanical Structure:

In order to acquire robust and reliable robots, Persia endeavors to make a fully omni-directional mechanism with a high factor of safety and low weight. Moreover simplifying of the mechanical structure , increasing the speed of robots and speeding up reassembling the parts of robots are other goals of designing and manufacturing good robots. In this way , two-year experience in Middle size league , using new ideas and simulating all parts of robots with the CAD/CAM softwares, help Persia to present new reliable fully omni-directional robots. Therefore, Persia exhibit three new innovations in mechanical structure:

1- Designing a single layer robot with a main structure which all parts of robot connected to. This type of structure decreases the weight , simplifies the assembly and reduces the size of robot's carry case. In reassembly, only ten bolts are needed to assemble each robot completely and all parts can be placed in a large suitcase. This design decreases the preparation time before each competition.

2-Designing a flexible chassis for encoder wheels that is known as a new odometry system for mobile robot that decreases the error of positioning of each robot. In this design, three omni-directional wheels are connected to special springs to move freely in three directions.

3- Designing a special holder for the mirror and the camera to protect them against ball collision and other external forces. This structure consists of a special transparent shatterproof material to connect the mirror indirectly to the camera. If external forces such as ball collision, affect this structure, the camera and the mirror are protected in this design. Special hyperbolic mirror is made of steel with NI-P electroless coating which have a good reflection on the mirror surface.

Self-Localization Using Enhanced Odometry System:

Odometry is a classic method which can help mobile robots to determine their position and head angle [10]. Although this method has great advantages over other self-localization approaches (i.e. vision based, laser range finders, GPS and etc), it suffers from great cumulative errors in long run. That is why this method is not widely used in MSL.

We believe that a few corrections in such method enable us to take advantage of its unique benefits like simplicity, cost efficiency and short term accuracy. Traditionally odometry sensors are coupled with driving units in mobile robots. Separating odometry sensors from the driving wheels is assumed to be a good solution for reducing errors like slippage in time of acceleration. Persia has developed and implemented the idea by three separate omni directional wheels coupled with shaft encoders placed 60° apart of the main driving wheels (fig. 1).

Free shaft rotation and the flexible connection to the structure ensures minimum slippage and firm contact of these wheels to the ground, all these result in a great improvement in output precision[9]. Having the shaft-encoder values, one can extract the robot position and orientation from *Direct Method* [9]. This method eliminates the differentiation and integration operations which are necessary in *Differential Method* [9].

Sudden faulty reports of the vision self-localization algorithm can be filtered out having the position and orientation report of the odometry system. In order to avoid the remaining cumulative error, odometry system parameters can be initialized every time the vision could calculate the position reliably (fig. 2).

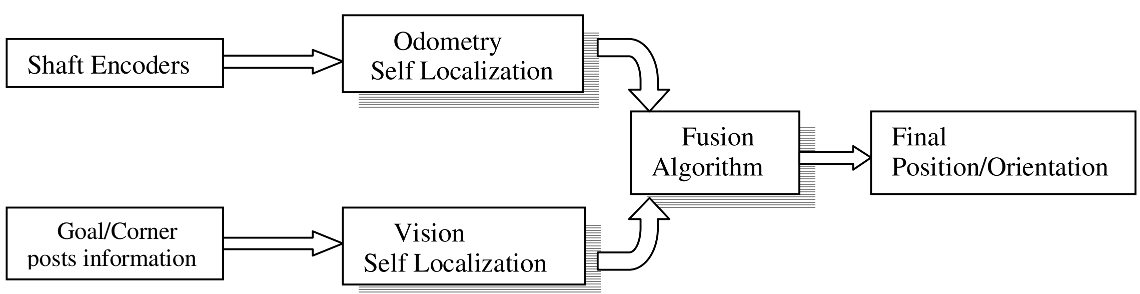

Fig. 2. The diagram above shows the overall mechanism of the self-localization system.

World Model Construction

Although each agent tries to extract the real world map as accurate as possible, but "noisy data" and "non-global, optimized" algorithms reduce the reliability of processed data. First let's clarify what is meant by "noise" and "optimized algorithms" with a few examples.

The flaws of color space modeling result in wrong color classification, which in turn makes the object detection algorithms error prone. As a result a robot may not see an opponent because of its poor color table for the opponent's tag color, or it may see an orange t-shirt in the spectators' area as a ball! These wrong outputs are referred as "noise". In this manner we're excluding the CCD noise pattern or faulty shaft encoder samples due to motors' noise.

There's a trade off between speed and reliability in most algorithms. Middle size league has a well-defined environment (e.g. distinct colors, defined sizes and etc) which can be very useful in simplifying the design of a fast algorithm. Since a predefined environment is assumed, any changes in this environment can more or less result in wrong results. For example, for self-localization the width of goals are assumed to be fully viewable in close situations; when an object taller than a robot (like a human) cuts or occludes a part of a goal in the image, the output of the vision self-localization module will no longer be valid. Detection of such a situation can be a very cumbersome task thus making the algorithm complicated and slow.

From the discussion above it's apparent that multi agent data fusion algorithms are necessary for constructing a better approximation of the real world. In addition to the software which resides on each robot, Persia team has developed a standalone software for network communication, world model construction, cooperative behavior management and game monitoring.

The world model module receives different data sets from every agent. Each data set contains different environmental information like self, ball and opponents' position(s). Each data carries a 'confidence' factor; a larger confidence factor means a more reliable piece of information. The most recent data sets are then chosen for data fusion, in which the following rules and facts are applied:

- Closer object are of more accuracy.
- Objects further than a specific distance could be said totally inaccurate. (This distance is experimentally known.)
- An object in the field can not move faster than an extreme.

With the fact above the module filters unwanted duplicates of objects (e.g. many opponents close to each other seen by different agents), calculates the best approximation for ball and opponents' positions with first order Kalman filtering, gives every object a confidence factor, applies a low pass filter on data and finally constructs a complete world model. This new world model contains information about the objects which may not have been seen by each agent correctly and also enhanced approximations of all environmental information. The constructed world model is then sent back to all agents so they will have a better view of the world around them!

Cooperative Behavior [6]

Soccer is a team play and while the final aim of RoboCup community is to develop a team of fully autonomous robots which can play against humans, it's apparent that cooperative behaviors are of great importance. Currently there're a few approaches to address this issue, each one could be placed under of the Centralized or Distributed regimes.

Since the problem of artificial intelligence is not so complicated in this case, Persia decided to choose the *centralized, role based* strategy. Each robot can accomplish a single task at a time which is called a *behavior*. One or more of these elementary *behaviors* which are necessary to accomplish a single task are grouped under a *role*. Sample behaviors are: *Rotate, KickBall, CatchBall, RightDefence,* etc. And *Dribbler, Supporter, Defender* are examples of roles.

In our approach a standalone server residing on a ground machine constructs an approximate world model. Then according to the world model, the *GameState*, and the playing strategy it picks three most necessary roles and assigns them to each active robot in the field. *GameState* is determined with two parameters.

1- The region in which the ball is currently inside.
2- The ownership status of the ball. (e.g. *OurTeam, OppTeam, FreeBall)*

For example a ball in the middle of the field, which is in our ownership, results in a *MedAttack* game status.

According to our overall strategy, there're predefined roles for each *GameState*, for example there can be *Dribbler, Supporter* and *Defender* in the *MedAttack* game state. The AI engine then assigns each role to the robot which gets the most qualification factor for that role.

In order to avoid unwanted bounces between roles of a single robot, there exist a hystresis module for each robot in the server software which accepts the roles decided by the AI engine, then from its past memory determines if the new role should be assigned or if the previous role is still the winner of the hystresis queue. This way the roles are somehow low pass filtered before assignment.

Conclusion

A team of fully autonomous robots in a dynamic multi agent environment which can play soccer need robust structural design, distributed information gathering/processing, cooperative behavior planning and efficient ball handling [8]. Persia team has attempted to reach an acceptable level in each of these areas. An optimized odometry mechanism is used in order to reduce the complexities of vision algorithms and enhancement in self-localization precision.

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