FURGBOL-PV Team Description Paper

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Abstract. FURG has been involved with RoboCup since 2001, having a dedicated research group for this end (FURGBOL). Currently, this group has been working in the Small-Size League, 2D Simulation League and Mixed Reality sub-league. In this paper, the groups's research status on mixed reality using the new Citizen Micro-robots is presented. Ongoing projects include the use of micro-robots in distributed immersion systems using CAVES, the application of the soccer platform in Artificial Intelligence classes, both for undergraduated and graduated students. Moreover, we show current and future contributions to the development of the physical platform for the Mixed Reality competitions.

1 Introduction

FURGBOL is a research group located at the *Núcleo de Computação e Automação* (NAUTEC) of the *Fundação Universidade Federal do Rio Grande* (FURG). It was created in 2001 and, since then, FURGBOL has participated in various RoboCup competitions and already accumulated expressive results. In RoboCup Brazil, FURGBOL won the last four competitions (2004, 2005, 2006 e 2007) in the Small-Size league. FURGBOL also participates in the 2D Simulation League since 2006, conquering a fourth place in RoboCup Brazil 2007. The main group motivation is to do innovative research in the areas of robotics, artificial intelligence and computational vision and create and improve the technology necessary to apply the research to real world problems.

In 2007, FURGBOL was selected to participate in the first Physical Visualization sub-league in Atlanta. In this opportunity, FURGBOL, named Brazil-PV2, rankings fifth place among the twelve competitors, despite the fact that the team only had access (due to problems with customs) to the actual robots the day before the competition began. Also in 2007, FURGBOL-PV participated in the Physical Visualization League in RoboCup Brazil, where it ranked second place.

FURGBOL participation in Mixed Reality Competitions intends to use the knowledge acquired in dealing with real and simulated robots in order to improve the technology required to use, apply and deploy Citizen's micro-robots. Our contributions focus the following aspects:

– improve the micro-robot platform by allowing it to become a standard testbed for multi-agent/multi-robots research;
– create scenarios for micro-robots in educational tasks;
– use the micro-robots in research in robotics and multi-robots systems;
– apply the contributions of the research using micro-robots in other areas;

FURGBOL has demonstrated good results in the last years through competitions and publications in journals and proceedings in the area [1] [2] [3] [4] [5]. FURGBOL has also directly participated in the development of the mixed reality standard platform, where we have been working in the automatic vision calibration system. NAUTEC possesses all the necessary infrastructure to work with the micro-robots: infrared communication, firmware programming and charging equipment, a 32ť LCD screen, cameras and computers.

This paper is organized as follows. In the next section, we present the acquired knowledge and group contributions to Robocup's Mixed Reality. The section 3 presents the current research developed using Citizen micro-robots. Section 4 describes projects using Citizen's micro-robots in education and research activities. Finally, section 5 summarizes and conclude the present paper.

2 Team Experience

FURGBOL is an experienced team able to contribute with the Mixed Reality League development, specially regarding the bridge between simulation and physical robotics and the cross-fertilization between different leagues. Besides Mixed Reality, FURGBOL has teams in Small Size and 2D Simulation League.

By competing in the Small-Size League, FURGBOL acquired knowledge about computational vision, distributed artificial intelligence, embedded electronics and mechanic devices control. In particular, FURGBOL has experience in issues such as camera drives, frame grabbing, camera calibration, undistortion, image filtering, color space transformations, blob detection and cross-correlation, image processing, robot localization, path planning and control.

Our robots were custom built from scratch using mostly inexpensive and easily extendible components and a modularized software environment. Our general architecture is composed of three main stages, as shown in figure 1 : (i) a deliberative stage, (ii) a communication stage and, (iii) a embedded reactive control. Robots uses omnidirectional wheels with independent electrical motors.

The Small-Size architecture is based on a combination of a local individual reactive control and central coordinated decision making for incremental plan adaptation to the multi-robot context. A Centralized Deliberative System is in charge of the global perception of the field and teams, identifying players, ball and boundaries, path planning and desired behaviors of each robot. The communication system exchanges information between robots and a Central Station (CS). Finally, we have a reactive embedded control. This stage receives the high level global information from the CS, reacting to local environmental changes [5].

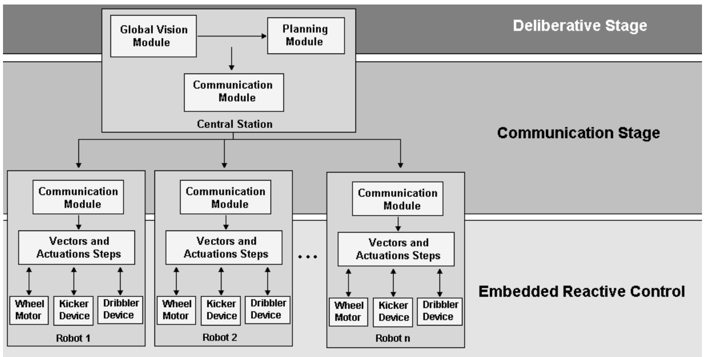

Fig. 1. FURGBOL F-180 Architecture

In 2D Simulation League, FURGBOL works in issues like multi-agent organization, environment states identification and reactive behavior coordination. More specifically, FURGBOL combines elements from multi-agent organization model $\mathcal{M}\text{oise}^{+}$ [6], concurrent autonomous agent architecture [7] and UvA Trilearn low-level behaviors[8]. The Moise+ model permits to constraint the actions subset in a given environment setting. The agent action is defined in submitting this subset to a set of predictive functions which chooses the best next state.

The $\mathcal{M}\text{oise}^{+}$ organization model define constraints to the agents behaviors through roles, goals and deontics aspects. These agents are structured through a concurrent autonomous architecture divided in three decision levels: reactive level, instinctive level and cognitive level. The cognitive level store data structures based on the organization model building the agent social knowledge. To the agent, this knowledge is expressed through roles, that has an individual context. These roles are sent to the instinctive level and are used to select the appropriate behavior in the reactive level. The reactive level is formed by a set of basic skills necessary to act in the environment, in this case, behaviors like kick, pass, catch the ball, and others. This level is implemented reusing the UvA Trilearn source code to low-level behaviors.

All the above experience in other leagues are being applied to the Mixed Reality league, adapting existing technologies to the micro-robot environment. The issues identified in last year's participation in RoboCup Atlanta and RoboCup Brazil are being tackled in this context. For that, the team relies on four professors and six graduate and undergraduate students.

Besides RoboCup, the group has been involved with other related research projects, working closely with other organizations outside the university. For instance, it has developed technology for educational robotics for schools, underwater robotics for exploration of resources such as petroleum and autonomous inspection vehicles for electrical companies.

3 Current Research in Mixed Reality

Our current research in Mixed Reality is twofold. We have developed soccer teams and demo applications for the RoboCup using the current and next-generation architecture and we have been collaborating for the development of the platform for other purposes.

3.1 RoboCup Soccer

In order to compete in RoboCup, we have been developing soccer strategies and demo applications in order to leverage usage of Citizen's micro-robots and their standard setup.

The development of our soccer team is largely influenced by our successful strategies in Small Size and 2D Simulation leagues. Our current strategy involves the exchange of roles between players. In response to the game dynamics, the goalkeeper can become the attacker, and the attacker become the goalkeeper. The high level strategy is based on a state machine, whose states are related to players and ball positions. The transitions in this state machine are determined by the game dynamic.

Our algorithm divide the field in four vertical regions. States are composed of the region the ball is in and who has the possession of the ball. In this way, it is possible to recognize when to take actions such as evading an offensive attack or guiding the ball towards the opponent's goal. Roles between players are exchangeable and each may adopt a defensive or attacking strategy according to their position on the field and in relation to the ball and adversaries.

For example, a player may acquire the role of the goalkeeper whenever the adversary has the ball and the player is close enough to its own goal. The goalkeeper has its own algorithm to defend the goal, according the figure 2. The key idea is to keep the goalkeeper between the ball and the goal's central line, since kicks are always made in a straight way (i.e. no curves).

An initial version of this high-level strategy ranked fifth in RoboCup Atlanta 2007 and second in RoboCup Brazil 2007.

Furthermore, we have developed a library that implement the very existent functions set but considering the global (inertial) reference frame instead of the frame attached to the robot.

3.2 RoboCup Demo Applications

In order to extend the use of Mixed Reality standard setup, we have been developing demo applications in the form of classic games that are playable in mixed reality. Two games were adapted to this new platform: the classics Pac-Man and BattleCity.

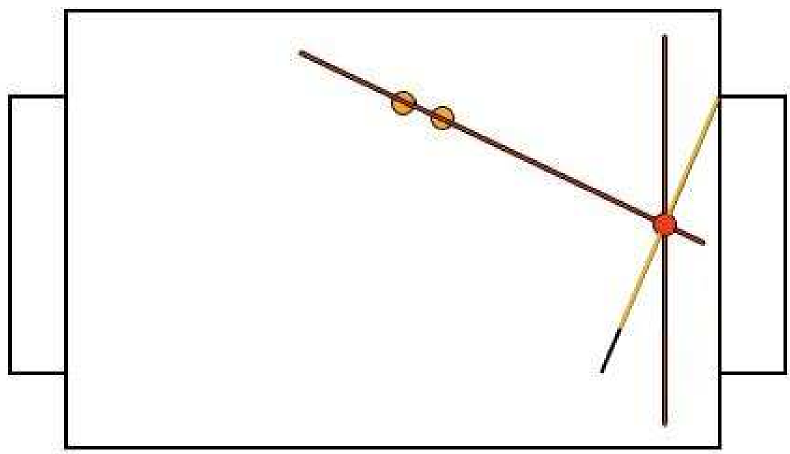

Fig. 2. Goalkeeper strategy

The Pac-Man is the well-known game where the player controls a character who must "eat" all the food in a maze while escaping from ghosts which may kill him. For this game, a micro- robot is used in place of the player's character while all other elements are simulated in the underlying video monitor. Since the maze severely constrains the movements of the robot, a central issue becomes to convincingly allow for the interaction of the robot with simulated aspects of the environment without damaging the gaming experience.

In BattleCity , players control tanks in a maze and must destroy all other players by shooting bullets. The maze can be destroyed by the bullets and have dynamic parts (such as moving bridges or gates). For this game, each player controls one micro-robot which plays the role of one tank. All other elements are simulated and rendered in the underlying video monitor. This is a step further compared to Pac-Man, since now not only the maze may constrain movements but it can also be dynamic and modifiable by the players' actions. Future implementations of this game will allow for real blocks to be put dynamically over the video monitor by the players, forcing the robots to interact with both real and virtual obstacles.

A 3D Citizen micro-robot model is also developed by our team. This virtual 3D structure was integrated with a 3D virtual scenario used in a Quake and UT (Unreal Tournament) game platform. Moreover, it is intended to implement a set of applications and games merging real micro-robots with simulated 3D environments.

For these applications, the next development step is to allow for a large number of micro-robots to play the game simultaneously. For Pac-Man, other robots would take place as ghosts and for Battle City, as other tanks or even dynamic obstacles. This will provide full benchmark scenarios for Multi-Agent and Multi-Robot coordination and competition.

3.3 Platform Development

In addition to RoboCup, our team has been collaborating with the creation of the next-generation platform for Citizen's micro-robots. In particular, we have been dealing with the problem of automatic camera calibration.

The process of camera calibration in the current system is a long and error-prone process as it requires a lot of interaction with the user. To automate this process will allow for calibration to take place faster and more often (or even continuously), reducing errors in detecting objects with the camera.

An automatic camera calibration is composed of the following main steps: (i) correcting distortions cause by lens and camera placement; (ii) recognizing colors and (iii) recognizing patterns.

The distortion correction step consists of displaying a standard pattern (like a grid) on the monitor and having this pattern being captured by the camera and processed by a correction algorithm. Since the pattern is known before hand, it is possible to compare what should be displayed with what is being captured by the camera and thus, the needed corrections can be made. Our algorithm recognize the nodes in a grid by color differentiation, obtaining a model of the captured grid and outputting correction parameters for the camera.

For the color recognition, it is required that the user put samples of the color in specific places over the monitor. These places are specified by the algorithm and displayed on the monitor. The algorithm then knows where to search for the color and is able to automatically calibrate, effectively learning to recognize that color.

Pattern recognition is related to identifying the unique pattern that identifies each robot. Our algorithm detects the central color in each pattern and then tries to identify the pattern around the color. The user may then specify which pattern corresponds to which ID or the system can have this mapped beforehand.

4 Mixed Reality in Research and Education in FURG

The Furgbol team has been envolved in various research and educational projects involving mixed reality. The group has been involved in an interdisciplinary research project, named SABERLANDIA ("Knowledgeland" in English) and granted by FINEP (www.finep.gov.br), and the main objective of this project is to build a low cost multimedia educational platform for fundamental school teaching. This platform is based on three modules: authoring, game and technological resources, allowing the creation of a virtual community for teaching and learning among the users. Our research team is working in the development of the mixed reality environment, with the presence of robotic agents and human users interacting locally or remotely. The system can be visualized using the CAVE already working in our laboratory.

The authoring module is responsible by the design and creation of different actors and scenes and definition of challeging tasks for a group of users of the system, that can interact with other groups in the real world using real tele-operated robotic systems or in the virtual world by 2D and 3D scenarios. In the game module all the educational aspects are considering, taking into account how the participants acquire the knowledge and the ways that they use to interact with the mixed virtual reality and with the other actors. Our proposal is implemented in a Quake-based platform (a well-known multi-platform game). The last module, the technological resources, is responsible by the design of the computational system, integrating different medias (videos, images, audio, etc), by development of the software that will execute in the platform and the project of low cost robotic systems.

Another project in development is a distributed immersion system using CAVE structures, robots and virtual agents based on mixed reality. In this framework, one has several different scenarios geographicaly separated. Some scenarios are equipped with cameras and tracking systems that capture the pose of different agents: humans, robots, etc. In other scenarios it will be possible to observe the entire dynamics captured virtually (or using robotic agents).

One can observe that, with the overall structure, it is possible to actuate in an environment far from the user, even geographically distant. Thus, with this telerobotic system, it is possible to monitor all the activities in an environment different from that one where the user and the manipulated object are located. Currently, we are working in the application of this framework in digital manufacturing system.

5 Conclusions

Citizen's micro-robots and the concept of mixed reality is being used at our University for research and educational purposes. FURGBOL's experience with autonomous robots, demonstrated in Robocup's Small-Size League and 2D Simulation League has built a knowledge base within the group that is helping and can further help the development of the mixed reality platform.

For instance, our group has been dealing and proposing solutions for problems such as global locomotion library, camera calibration, image filtering, color space transformations, multi-robots and multi-agent system. For instance, we have implemented two different applications: Pac-Man and BattleCity. We are working on testing a version of an automatic camera calibration that will greatly reduce setup time of the platform.

In addition to infrastructure, our group has been experimenting with using the platform for multi-robot and multi-agent research and as an educational tool for undergraduate and graduate students.

The new generation of micro-robots will help maintain and expand these projects at our University, while allowing for the creation of new projects that make full use of the new features.

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