

FLEA 2009

Team Description Paper

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Abstract. This paper provides a description of the FLEA robocup team as well as a description of the robot FLEA. The team FLEA consists of three robot enthusiasts. The team's robot is called FLEA which stands for Friendly Learning Electronic Assistant. It is able to understand spoken commands, talk, navigate safely in indoor environments and recognize persons and objects.

Keywords: FLEA, robot, RoboCup@Home, computer vision, human-robot-interaction.

1 Introduction

FLEA was founded as a students-only team in 2006 with the intention to participate in the newly-created RoboCup@Home competitions. FLEA is the short term for "Friendly Electronic Learning Assistant". In 2007 FLEA won the 2nd place at the RoboCup@Home German Open (Hannover) and successfully participated at the world championship in RoboCup@Home 2007 (Atlanta / USA).

This paper describes the idea and the infrastructure behind FLEA team and robot. The second chapter of this paper gives a brief overview on the history of the FLEA team and its team members. The third chapter describes the team's robot for the 2009 RoboCup@Home championship with emphasis on the hardware components. The fourth chapter describes the software architecture of the 2009 robot.

2 FLEA Team

The team FLEA was founded by Joachim Pehserl and Petra Korica-Pehserl in August 2006 at the Graz University of Technology. Currently it consists out of three persons: Joachim Pehserl, Rudolf Rösler and Petra Korica-Pehserl. The team has a strong focus on hardware prototyping and robotic software development. The main research interest of FLEA is robotic computer vision and human-robot-interaction. Due to the strong binding to the Graz University of Technology several master theses and

student projects originate out of the FLEA project. Currently the FLEA robot is used as a platform for a master thesis in computer science. The focus of this thesis is on the “Competitive Lost & Found” test of RoboCup@Home.

FLEA team cooperates with many institutes from Graz University of Technology: Institute for Computer Graphics and Vision, Institute for Software Technology, Signal Processing and Speech Communication Laboratory and Institute for Theoretical Computer Science.

3 The Robot FLEA

This chapter describes the hardware setup of FLEA robot. In section 3.1 we discuss the robotic system used in 2007 which is the foundation of the new system which we describe in section 3.2. We mainly intend to use the new system at the 2009 RoboCup@Home competitions.

3.1 FLEA 2006-2008

In 2007 and 2008 the robot FLEA consisted out of an ActivMedia Peoplebot platform and a self-made robotic head with 13 DOF called “NOVA”.



Fig. 1. The FLEA robot 2007/2008 (Pioneer Peoplebot & NOVA)

The figure above shows our self-made robotic head NOVA set on top of the Pioneer PeopleBot. NOVA was designed as an innovative user interface for human-computer-interaction. She has thirteen degrees of freedom and moves her eyes, mouth, eyebrows, forehead, chin and neck. When she talks her mouth moves naturally to the

spoken words. Her eyes are looking at the person she is talking to. She pays attention to things around her. When she sees something interesting (e.g. a human) she looks at it and moves her eyes according to the movement of the person.

Due to her advanced animatronics she is able to communicate in a natural and intuitive way with her environment by expressing her feelings using mimics. She can be happy and smile or be surprised by raising her eyebrows. In 2008 the abilities of NOVA were enhanced by a master thesis [1] in the research field of computer vision. NOVA is now able to recognize the six generic facial expressions of a person which are the same for every human being: happiness, anger, sadness, fear, surprise and disgust. NOVA can recognize and distinguish whether a person is happy or scared. This capability can enhance human-robot-interaction by allowing non-verbal communication with the robot – this is very important as we know that most of the communication happens on a non-verbal level [1].

3.2 FLEA 2009

Due to hardware problems, in 2008 we started the development of a new robotic platform. All in all, the FLEA 2009 robot can be seen as a further development of the FLEA 2007/2008 with the focus on indoor robotics and RoboCup@Home.

The robotic system has been developed from scratch. A development snapshot is depicted in figure 2. FLEA consists of the following hardware components:

- Steel and aluminum frame
- Plastic chassis
- Differential drive system (CAN-BUS)
- 24V working voltage
- High capacity lead gel battery ensures runtimes greater than 12 hours
- Stable maximum speed of over one meter/second
- Leuze ROD4 laser scanner
- Intel Core Duo 2GHz, 1024 MB RAM
- 10" touch screen
- Stereo webcam
- Infrared sensors
- Ultrasound sensors
- Bumper
- Emergency stop buzzer
- Microphone and speakers
- Height: approx. 1 meter
- Width: approx. 0.4 meter
- Weight: approx. 50kg
- Charging station (robot can be fully charged within 4 hours)



Fig. 2. The FLEA robot 2008/2009 (development snapshot)

4 Software Architecture

The entire software of FLEA has been rewritten from scratch using the most advanced and functional modules of the 2007/2008 model (including NOVA). FLEA 2009 has an optimized computing concept. Unlike the predecessor from 2007/2008 the new model does not have a hybrid and distributed computing system (Linux, Windows). The 2009 robot uses only one computer with Windows XP as the operating system!

The robot software is entirely written in C++ using MS Visual Studio 2005. The application is heavily threaded, making use of the onboard multi core architecture.

FLEA uses the well known Monte Carlo Localization method [2] for global localization. The path planning is performed using A* (global) and Wavefront (local) planning. Speech recognition and synthesis is done using the Microsoft Speech SDK. Figure 3 shows an overview of the architecture.

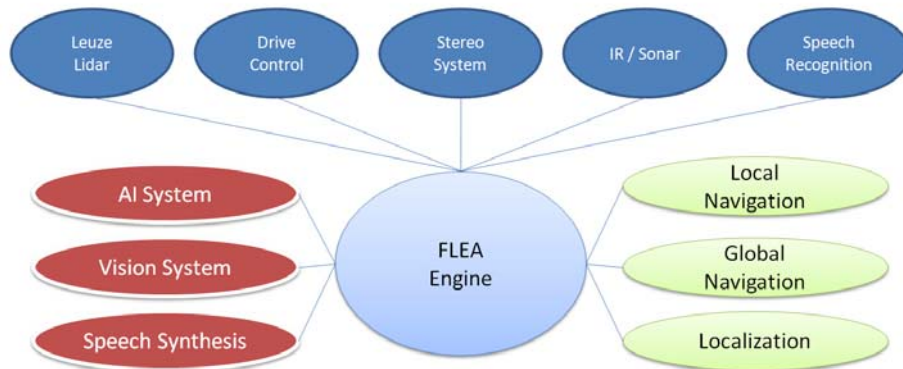


Fig. 3. FLEA 2009 system overview

One of the main components, the computer vision system, is described in the following section.

4.1 Vision system

Similar to us humans, visual perception is also vital for a mobile robot. Using the stereo camera system FLEA analyzes images for possible obstacles, known places, objects and persons.

FLEA uses the “fast approximated sift” object recognition system for object recognition (aSift) [3]. aSIFT features are fast computable local features [4] that can be used for object recognition (wide baseline matching) or panorama stitching. The aSIFT features are computed using integral data structures and are therefore applicable for realtime use. Figure 4 shows an example of feature matching using aSIFT features.

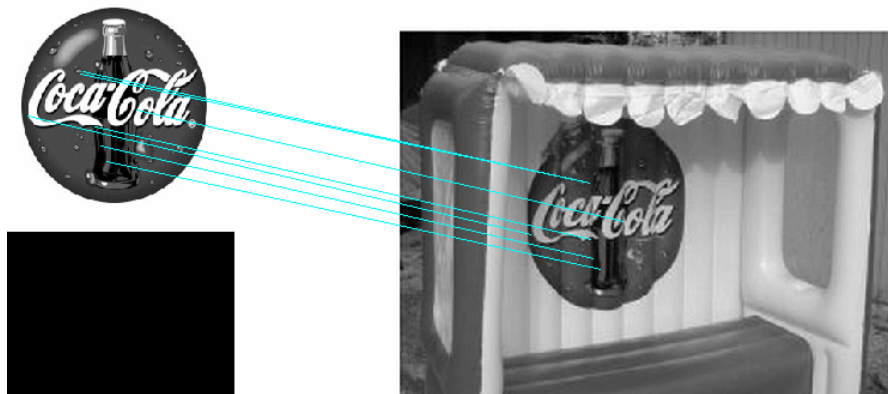


Fig. 4. Approximated SIFT features for object recognition: Example matches

FLEA can be trained on new objects at runtime. Training a new object can be done within a few seconds. This enables FLEA to easily learn and adapt to dynamic home and office environment.

4.2 Face detection, recognition and facial expression recognition

The ability to detect and recognize individuals is essential for an autonomous robot in order to interact with human beings. In general a small user group can be assumed for interaction with the robot. The robot has to distinguish between multiple users and further on between known and unknown persons.

For solving this problem we use an approach which integrates detection, recognition and tracking by formulating all tasks as binary classification problems. The implemented approach is efficient and well suited for the use in robotic systems. In [5] we demonstrate robustness and comparable results to state-of-the-art approaches. We use a common over-complete representation which is shared by the different modules. By means of the integral data structure an efficient feature computation is performed.

In addition the face recognition approach has been extended to analyze facial expressions. FLEA is now able to distinguish the six primal emotions of humans [1].

4.2 List of external software components

We also use some external software libraries for different functionality in our robot. This subchapter enlists these components, which are:

OpenCV – Open Source Computer Vision Library
SAPI – Microsoft Speech SDK

5 Conclusion

The FLEA RoboCup@Home team has already participated in the RoboCup@Home 2007 competitions. For the 2009 competitions we have constructed a new robot. The research focus of the team is on computer vision for robotics. FLEA has been successfully used for transportation tasks at the Institute for Computer Graphics and Vision, appeared on the Austrian TV, radio, press, and won the 2nd place at the RoboCup German Open 2007. In the future FLEA can also be used in an office environment or at home.

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