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DESIGNING A WEB BASED SOFTWARE CONTROL SYSTEM FOR SERVICE ROBOT AND SEQUENCE PROGRAMMING USING SCRIPTING LANGUAGE EDITOR

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Abstract: *The article focuses on the design and development of control software and user interface for service mobile robot and its possible usage in socialization of children with ASD (Autism Spectrum Disorders). The system enables the robot operator to program various educational and training sequences using web based script editor and to interact with the trainees in real time.*

Key words: *Service Robots, Software control, User Interface, Mobile Robots, Modular Robots, web based, PHP, Children, Autism, ASD*

1. INTRODUCTION[1]

Autism Spectrum Disorder (ASD) is characterized by having deficits in social skills, engaging in repetitive behaviors, and having challenges with speech and non-verbal communication. Currently autism has no real cure, but treating the medical conditions that aggravate autism symptoms can drastically improve the child's health. Prevalence studies of ASD with an age range of birth to adulthood throughout the world, it is reported to be 1 in 150 children. The current rates of autism in the European Union depending of the study and forms of ASD counted varies from 1.9/10000 to 72/10000.

Most recent studies shows that children are adopting robot interaction very easily and naturally. Especially on children with ASD (Autism Spectrum Disorders) a robot can be a social mediator and also may be used for teaching. The machine can train and create new social behavior which is normally is a very hard goal to achieve by a human with children having this kind of disorders.

From the technical side there is a practical requirement to make a service robot that can perform various presentation and game scenarios which through entertainment of the children can help them to develop social skills. Also there is a need for appropriate control software that enables the operator in collaboration with the autism program specialists to program the robot and to interact and moderate the behavior during the children sessions in realtime.

II. HARDWARE PLATFORM OF THE SERVICE ROBOT

The development and tests are performed on a service robot, developed in the Institute of Robotics at Bulgarian Academy of Sciences which consists of the following components:

- Mobile Robot Platform with differential drive using 2 DC motor driven and 2 center orientable wheels, built on a modular principle;
- 6 DOF Robot Arm with a gripper, which allows different tasks to be performed like fetching and manipulating of objects;
- The electronics of the robot uses modern 32bit Arm MCU architecture I/O boards interfaced internally via CAN and bridged to an Ethernet network interface;
- The robot control is provided via standard PC with Ubuntu Linux OS;
- The networking is done using a standard WiFi 802.11an router. The router integrated switch is used for the internal networking between the computer and the I/O boards;
- A two channel amplified audio subsystem is connected to the computer for the speech synthesis and multimedia playback;
- Color LED display attached on the head level of the robot, enables robot do display various media and emotion state;

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- Sensors – which include various contact sensors, infrared sensors and ultrasound sensors for safety and obstacle detection;
- Cameras – to capture images and video and enable further processing, by various algorithms;
- The communication between the PC and the I/O subsystem is standard TCP/IP socket based;
- The robot is powered by Lithium-Ion battery with battery management and charging station.

III. SOFTWARE

1. Requirements

In order the conclude different scenarios and presentational sessions the following requirements were defined during the planing phase:
The operator should be able to connect remotely and control the robot using the WiFi interface. Programming of the robot should be implemented using a script editor embedded in the web interface.
There should be a function for media file management (audio, video, images) that can be uploaded to the robot hard drive;
Ability to read text via text to speech engine (TTS);
The robot should also be able to display an its 'emotion' state.

2. Software architecture

The backbone of control system consists of web server – Apache with PHP scripting language module installed. There is a MySQL database server running to store and manage texts, parameters and logging information.

In addition to the database there are dedicated storage for the various type of content – images, audio, video files, emoji and etc.
The software architecture is shown fig.1:

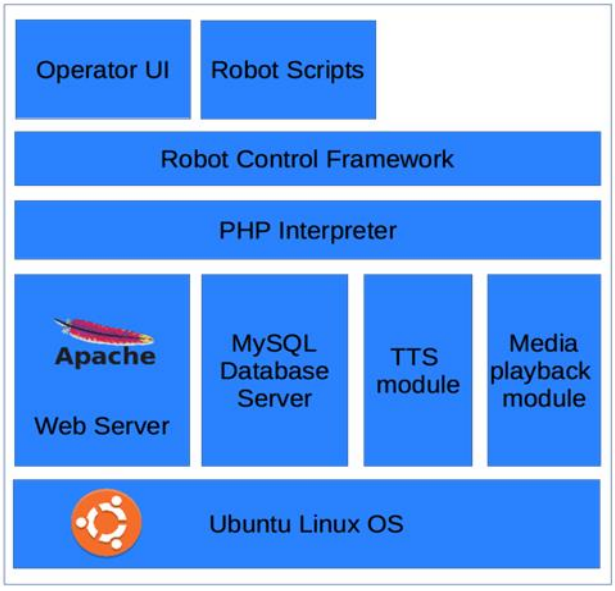

Fig.1: Software Architecture of the system

The robot specific function set is realized as a PHP library, created especially for the specific robot. Most of the controls are done using TCP sockets to control the robot I/O subsystem read the sensors and etc.

3. Robot specific functions

Entirely for the purpose of the service robot the following library of functions were developed. The type of functions are created for the robot specific application are show on fig. 2:

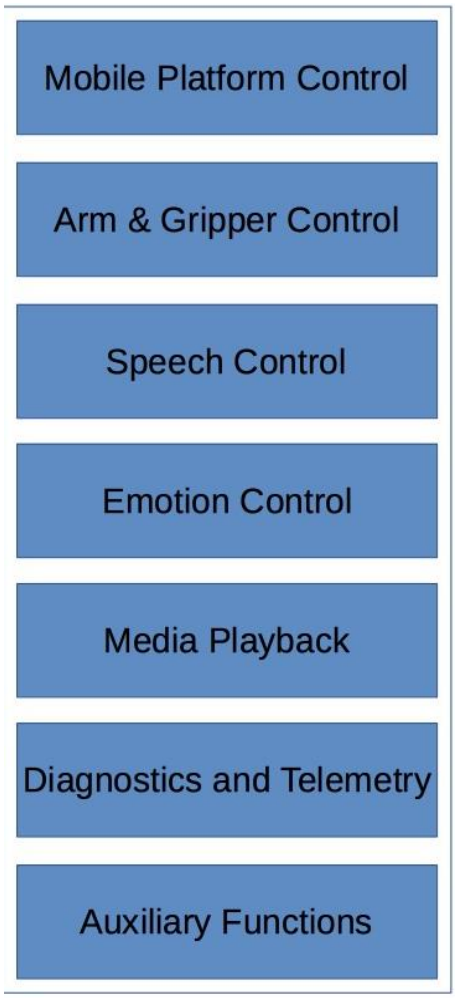

Fig.2: Robot control function types

3.1. Functions for movement of the robot mobile platform:

move_base($offset) *- controls the robot base movement in forward and backward directions;*

rotate_base($angle) *– controls the robot base rotation.*

3.2. Functions for movement of the arm and gripper control

brake_disable() *- disables the electromagnetic safety brakes of the robot arm;*

brake_enable() *- enables the electromagnetic safety brakes of the robot arm;*

arm_position($position, $axis) *– moves the specified robot arm axis to a specified position;*

3.3. Functions for speech synthesis

say($text, $language, $pitch, $word_gap, $speech_speed) *– reads the text with the specified language, voice pitch, speed and word gap using the text to speech (TTS) engine.*

3.4. Functions for local multimedia playback

get_audio_list() *– returns an array with the available local audio files and its durations;*

get_video_list() *– returns an array with the available local video files and its durations;*

get_image_list() *– returns an array with the available local image files;*

audio_play($ID) *– plays and locally stored audio file;*

video_play($ID) *– plays and locally stored video file;*

image_show($ID, $duration) *– displays an image for a specified duration;*

show_emoji($emoji, $duration) *– displays a specified robot 'emotion' for a specified duration;*

blank_screen() *– blanks the media display until the next playback command;*

3.5. Functions for diagnostics and telemetry

get_status() *– reads the full status of the service robot;*

get_battery() *– reads the battery level of the service robot;*

get_arm_position() *– returns the current positions of the arm of the service robot;*

get_sensors() *– reads the sensor states of the service robot;*

3.6. Auxiliary functions

reset($what) *– resets the specified robot subsystem;*

output($output, $value) *– controls the digital outputs of the main I/O board of the robot;*

pwm($output, $value) *– controls the PWM outputs of the main I/O board of the robot;*

sequence_move($ID) – *executes defined sequence of movements of robot base and arm.*

take_photo($cam) – *captures a photo using the specified robot camera.*

4. The Operator's User Interface (UI)

The frontend of the UI is realized as a HTML/Javascript web application.
The current version includes the following set of features:

- script editor;
- script management (create, edit, delete, run, stop);
- robot status and health monitoring;
- media files management (upload, delete, preview);
- speech engine (TTS) control;
- robot 'emotion' state control;
- set of predefined robot sequences;

The backend is realized as a set of PHP scripts, some of the features – such as media play and TTS are done as external calls.
A screenshot of interface is shown on fig.3:

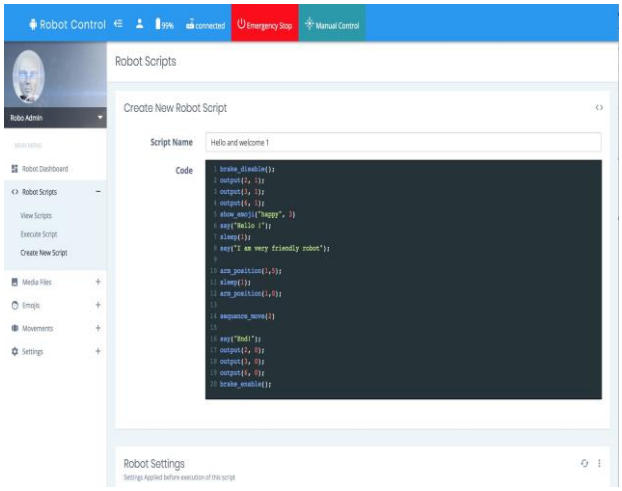

Fig. 3: Script programming in the Robot user interface

V. SAFETY CONCERNS AND MEASURES.

The safety measures especially for service robots are extremely important. Since the robot interacts with children multilevel safety measures should be implemented:

On the software side there is a software "Emergency Stop" button that cancels all current running scripts and enables the safety brakes of the arm. Various program error checks and warnings are performed before script execution.

On the hardware side separately, there is a "Stop" button mounted on the robot's platform, which is accessible at any time, and can be triggered to terminate the robot's operation. Also watchdog timers are implemented on the firmware for the I/O subsystem.

The personal is trained to program sessions in a way to avoid direct physical contact between the robot and the trained youth. As an example the use of an intermediary surface, such as a table on which objects to be placed are manipulated and from which the learner can take them.

The robot is equipped with various sensors to avoid obstacles on the mobile base path. The robot is battery powered and uses no dangerous voltages and also all the movements are very limited in the speed and torque.
All the measures are taken to eliminate most of the risks which can exist in a case of unexpected robot failure

V. POSSIBLE SCENARIOS FOR TRAINING SESSIONS FOR CHILDREN WITH ASD

Some example scenarios can be realized using the current system based on suggestions from the collaborative sessions with pedagogues and ASD specialists:

- Visualize an object on the screen and ask the child a question. If the answer is correct then show happy emotion and perform a 'robot dance'
- Play a teaching movie and ask the children related questions;
- Advertise somebody which will enter the room, allowing time to the children to be prepared and to socialize easier with the new person;

Using the flexible scripting engine there are vast amount of options for realization of teaching and therapy sessions.

VI. CONCLUSION

The usage of service robots in education and therapy of children with special needs offers serious advantages. Usage of scripting languages with intuitive robot control functions and web based for the robot can give access to more specialists to develop training and social skills improvement sessions.

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