Remote Robot Controller using TCP/IP connection.

ERTS Embedded Systems lab project
IIT Bombay, 2012

Group 3

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Problem Statement

- This Project aims at controlling robot remotely through TCP/IP connection from any place in the world.
- Assistance of Video feed is provided from robot to control it at user side.

Introduction

- “Burglary Detection Robot”
  - Robot is put on surveillance with its camera on.
  - Whenever it detects motion it sends SMS to owner.
  - Owner then can watch video remotely coming from camera of robot.
  - User can also move robot remotely, he can turn on buzzer on robot remotely and this is constantly aided by video feed.

Requirements-General

- Robot having following functionalities:
  - Processor to manage various tasks.
  - Capable of moving in all directions
  - Wi-Fi module to establish TCP/IP connection
  - Camera to provide Video feed
  - Buzzer to signal alarm

- Android Phone/Any smart device to control robot remotely.
  - Wi-Fi module to establish TCP/IP link.

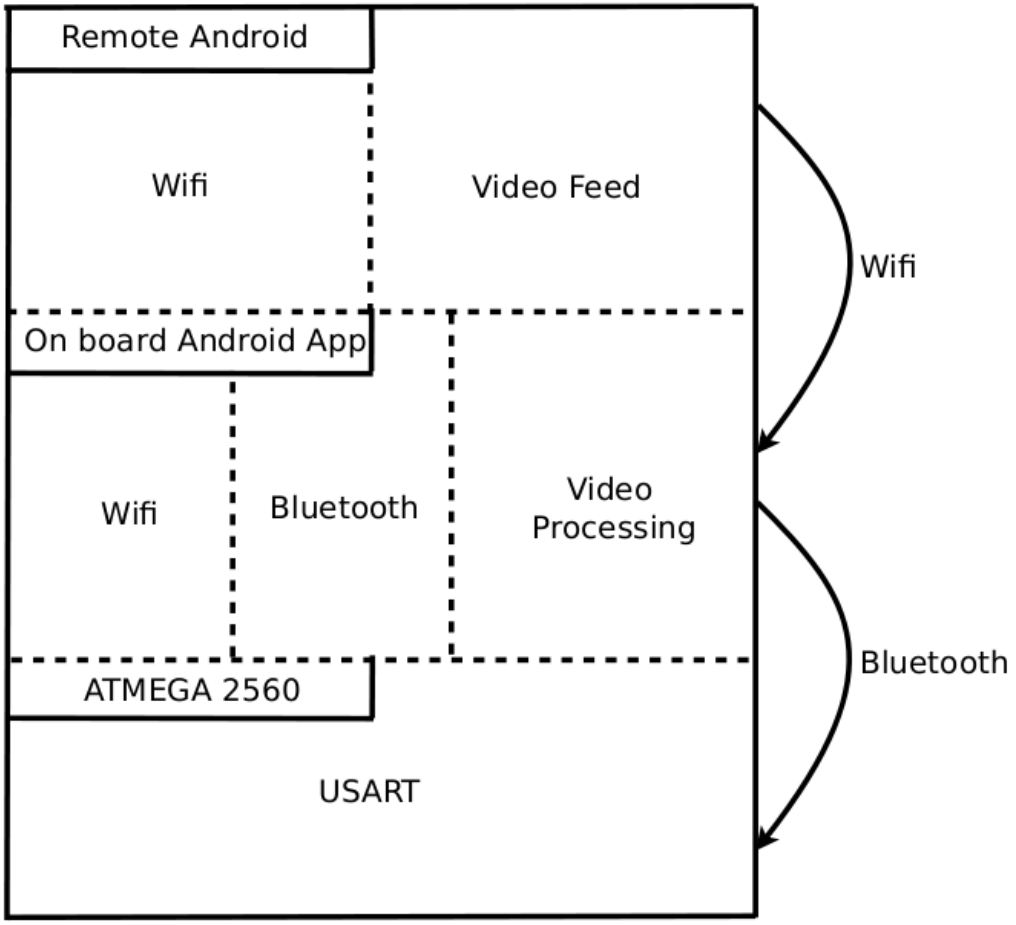
Requirements –Specific

- Robot :
  - FireBird V
    - Supports motions, buzzer functionality and asynchronous communication using Atmega2560 (slave controller) attached on robot.
  - Android phone mounted on FireBird V.
    - Camera on mobile phone is used for video feed.
    - Wi-Fi module in mobile is used to establish TCP/IP connection
    - Processor on mobile (master controller) is used to manage all tasks
- Remote Smart Device:
  - Android phone to control this robot remotely.

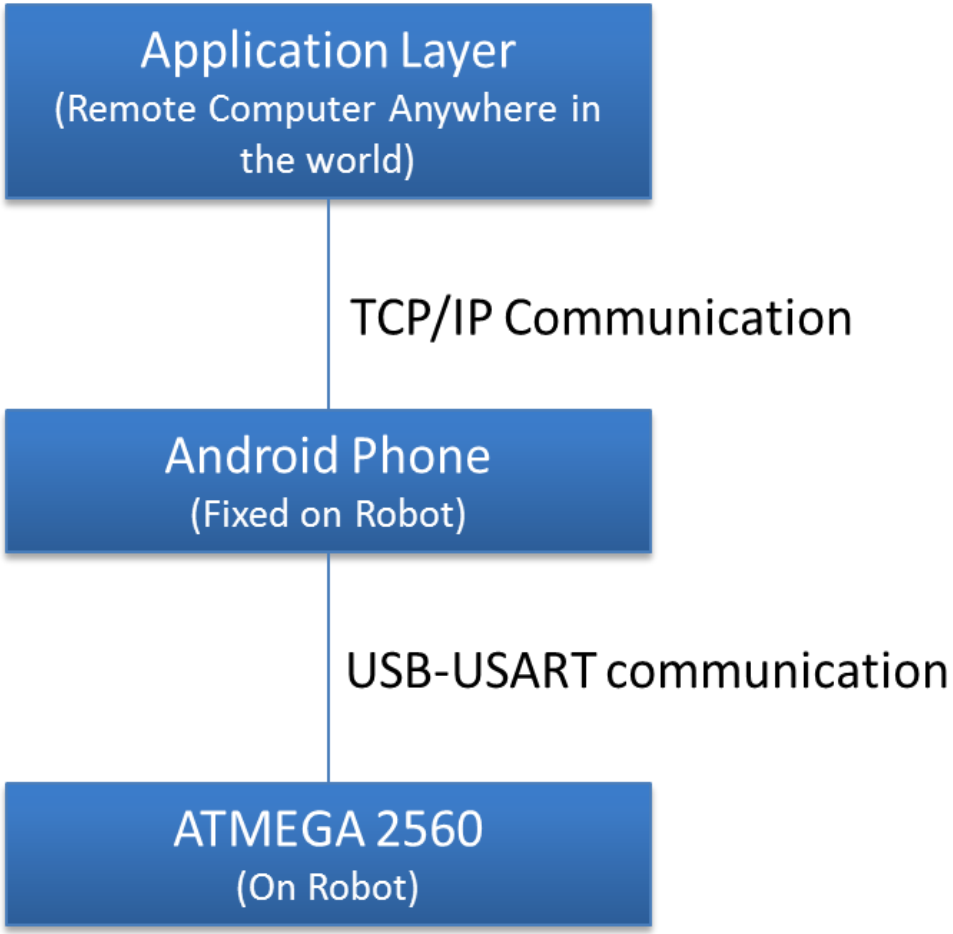
Specifications –

- One Android Mobile phone
  - Wi-Fi, camera and Bluetooth
- One Android Mobile phone
  - Wi-Fi module
- Android phone
  - OS > 2.3.4 preferable on both
- Firebird V robot
- IOIO board/ Bluetooth module – for communication between android and Atmega2560

State Diagram

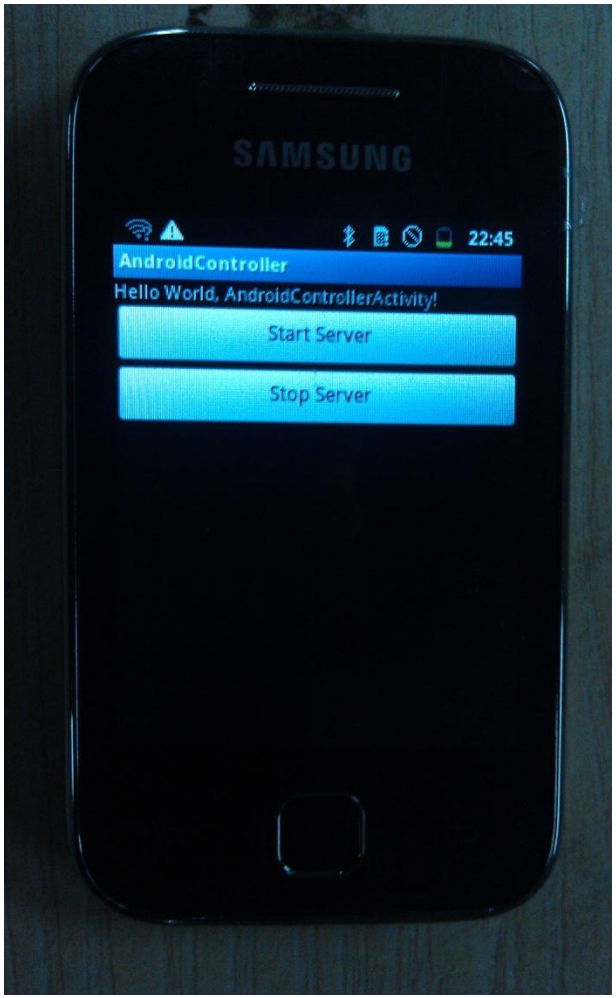


Modules


Application Layer
(Remote Computer Anywhere in the world)
TCP/IP Communication
Android Phone
(Fixed on Robot)
USB-USART communication
ATMEGA 2560
(On Robot)

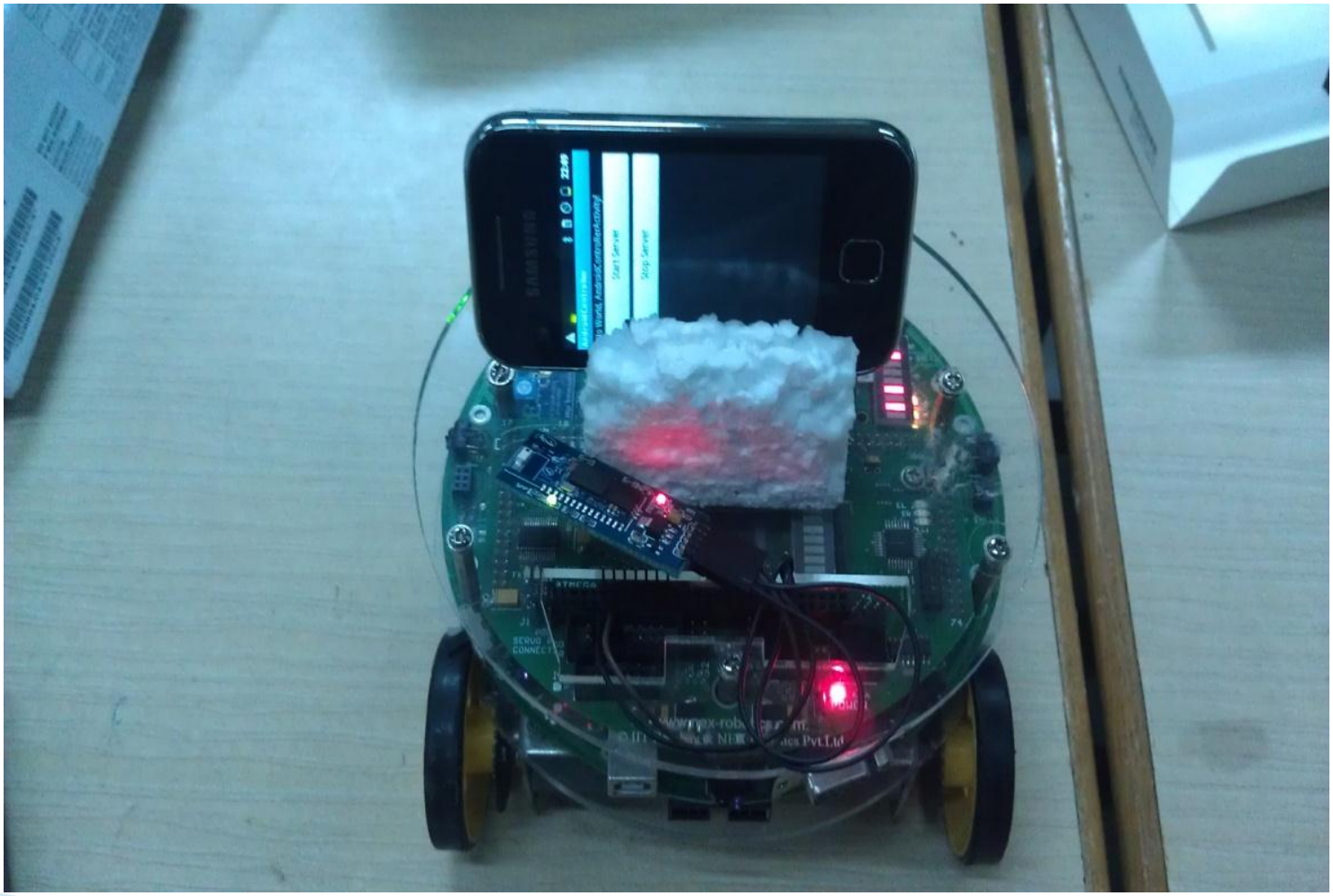
Android Application

Remote Controller



On Board Controller

Robot Assembly



Modules

Three Modules of Processing:

- ATMega2560 Application:
  - managing robot movement
  - Bluetooth receiver
- On Board Android application
  - Managing Video transmission
  - Wi-Fi connection with remote android
  - Bluetooth communication with atmega2560
- Remote Android application
  - Manages Video reception
  - Dashboard to move robot

Innovations

- Established mechanism to have Wi-Fi communication between robot and remote device.
- Developed code for Video transmission and reception over Wi-Fi.
- Used IOIO board as means of communication between android and Bluetooth.

Project Plan

- Parallel work was started in all three major modules.
- Critical tasks and TimeLine
  - Getting Wi-Fi connection to work (Completed before 21 March)
  - Getting Video to work (30 March)
  - Getting IOIO/Bluetooth communication to work (4 April)
- Work Division
  - Saif: Onboard Android application
  - Sagar, Saif – Remote android application
  - Sagar, Saif – TxtWeb Application
  - Hemant, Chinmay – FireBirdV robot coding
  - Sagar, Hemant, Chinmay – IOIO communication/Bluetooth communication
  - All : Final Testing, Documentation, Reports, Presentation

Tasks

- **Challenges Faced**
  - Shorting of IOIO board while testing.
  - Reading raw video and audio data from Mobile Hardware
  - Converting the raw data into a proper image(audio) format in order to display(play) on computer
- **Response**
  - Finally used Bluetooth instead of IOIO.
  - Use of core android libraries to extract raw data
  - Use of external library which can convert the raw image data provided by hardware into a readable format

Tasks

- **Challenge**
  - Building multi tasking application on android which can simultaneously interact with robot as well as with user application along with audio and video streaming.
- **Response**
  - Thread based programming. Separate Threads for Video transmission, Wi-Fi Connection, Bluetooth communication

Testing

- Test Criteria
  - Layered Code structure
  - Each layer was tested independently using Android USB Debugging mode.
  - Proper communication between various layers.
  - Packets received over Wi-Fi are in order of their transmission.
  - Tested on three different platforms.
    - HTC Incredible S (Android 2.3.5)
    - Samsung Galaxy Y (Android 2.3.6)
    - Sony Xperia Neo V (Android 2.3.4)

Testing

- Test Description
  - Android application development was done in Eclipse using Android SDK
  - Some things were tested on emulator, plug-in for eclipse.
  - Android Logcat was used extensively to view debugging messages.
  - Step by step testing on actual hardware device.
    - Getting Bluetooth link up
    - Getting Wi-Fi Link up
    - Getting Video transmission working
    - Getting control signals transmission working.

Performance Metrics

- Quality vs. Reliability of video streaming
  - Currently we are transmitting 10 frames/sec from camera for video.
    - Each frame size ~ 10kb per frame.
    - Data Transfer - 10Kb * 10 = 0.1 Mb/sec
  - Maximum frame limit depends on available bandwidth of Wi-Fi. Android literature specifies upto 60 fps.
  - Improving number of frames may increase quality but because of heavy bandwidth utilization video starts lagging.

Performance Metrics

- Ease of setup vs. cost
  - Android phone – costly but easy to setup.
  - Onboard android can be replaced by Beagle board and separate modules of Wi-Fi transmitter/receiver ,IP camera.
  - Reduces cost and makes on-board android phone redundant.
  - Difficult to setup and integrate these modules with FireBirdV.

Reusability

- Generic communication model
  - For transmission and reception over TCP/IP connection.. Different applications can use it.
- Generic Code
  - Some other data packets for example audio packets can be sent by using same code.
- Independent of robot.
  - Bluetooth can be replaced with IOIO board. Firebird / Atmega2560 can be replaced by any robot.

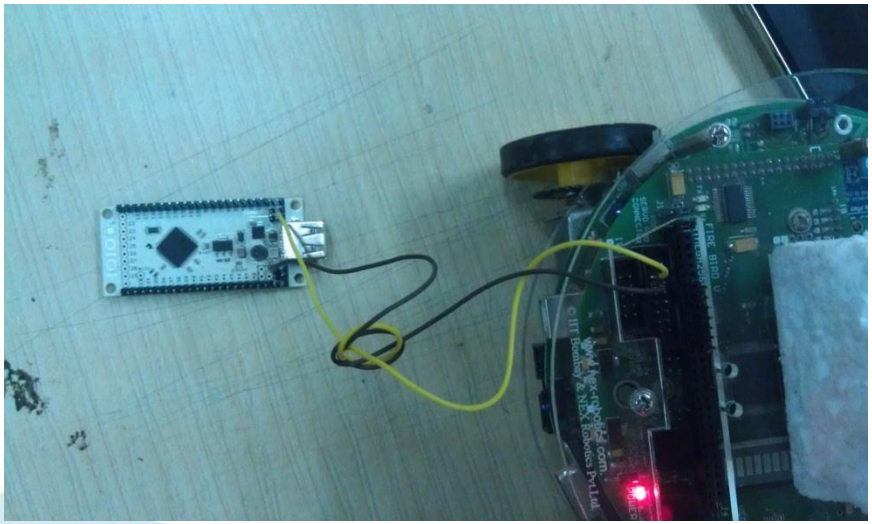
Applications

- Theft detection robot:
  - We have implemented prototype of this application by SMS alert facility.

- Remote Surveillance robot:
  - Monitoring foreign terrain like border surveillance.

Future Work

- Audio can be transmitted along with video for more information about robot's environment.
- Accelerometer on android can be used to control robot.
- Using more reliable communication between android and Atmega like IOIO board.



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THANK YOU

- Entire ERTS team for providing excellent opportunity and support.

- Special thanks:
  - Piyush, Akshat, Saurabh