InnoSoc
Innovative ICT Solutions
for the Societal Challenges

AMBIENT INTELLIGENCE FOR ACTIVE AND ASSISTED LIVING

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UNIVERSITAT POLITÈCNICA DE VALÈNCIA

SUMMARY

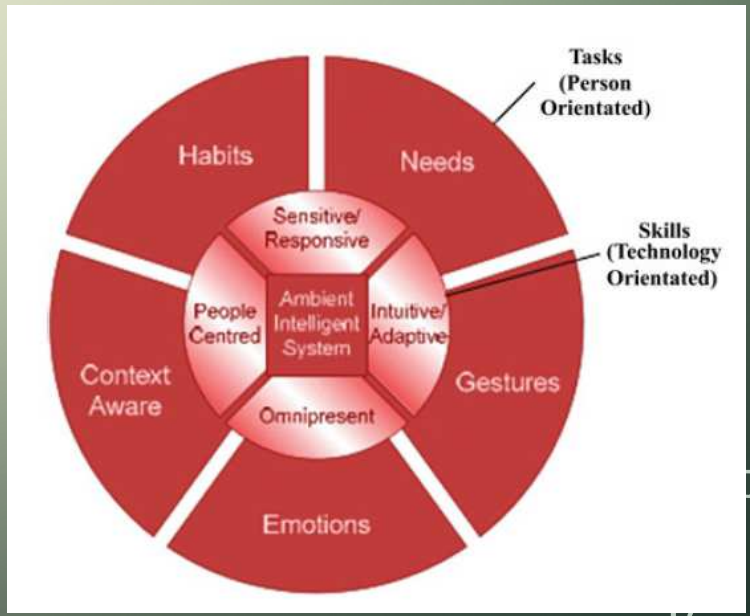
- Ambient Intelligence
- AAL (ACTIVE AND ASSISTED LIVING)
  - Ambient systems
  - Wearable systems
  - Assistive robots
- Activity recognition
- Case studies

AMBIENT INTELLIGENCE

- **Ambient Intelligence?**
  - ambient intelligence (AmI) refers to electronic environments that are sensitive and responsive to the presence of people. Ambient intelligence is a vision on the future of consumer electronics, telecommunications and computing that was originally developed in the late 1990s by Eli Zelkha and his team at Palo Alto Ventures for the time frame 2010–2020.
  - In an ambient intelligence world, devices work in concert to support people in carrying out their everyday life activities, tasks and rituals in an easy, natural way using information and intelligence that is hidden in the network connecting these devices (Internet of Things).
  - As these devices are smaller, more connected and more integrated into our environment, the technology disappears into our surroundings until only the user interface remains perceivable by users.

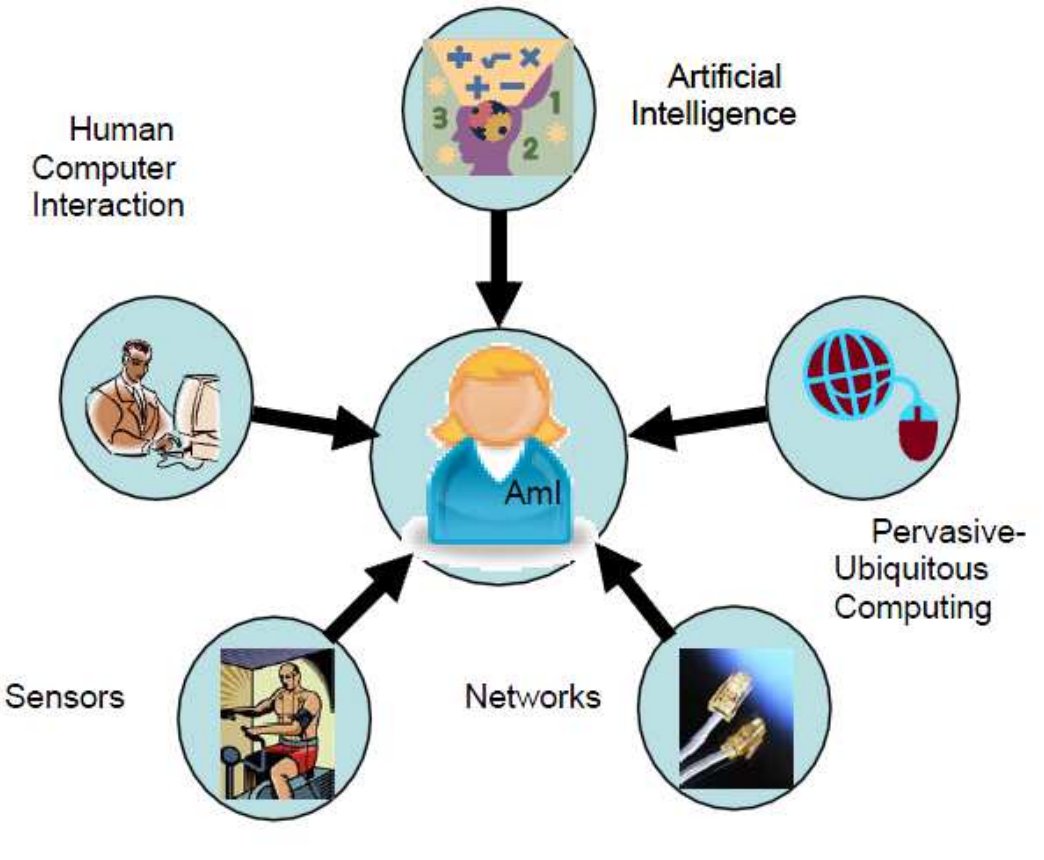
AMBIENT INTELLIGENCE

- The ambient intelligence paradigm builds upon pervasive computing, ubiquitous computing, context awareness, and human-centric computer interaction design and is characterized by systems and technologies that are (Zelkha et al. 1998; Aarts, Harwig & Schuurmans 2001):
  - **embedded**: many networked devices are integrated into the environment
  - **context aware**: these devices can recognize you and your situational context
  - **personalized**: they can be tailored to your needs
  - **adaptive**: they can change in response to you
  - **anticipatory**: they can anticipate your desires



AMBIENT INTELLIGENCE - OVERVIEW

- Basic technologies:
  - *Embedded System technologies*
  - Communication technologies
  - Sensors
  - Artificial Intelligence
- Future of IT characterized by terms such as:
  - Disappearing computer
  - Ubiquitous computing
  - Pervasive computing
  - Post-PC era
  - Cyber-physical systems



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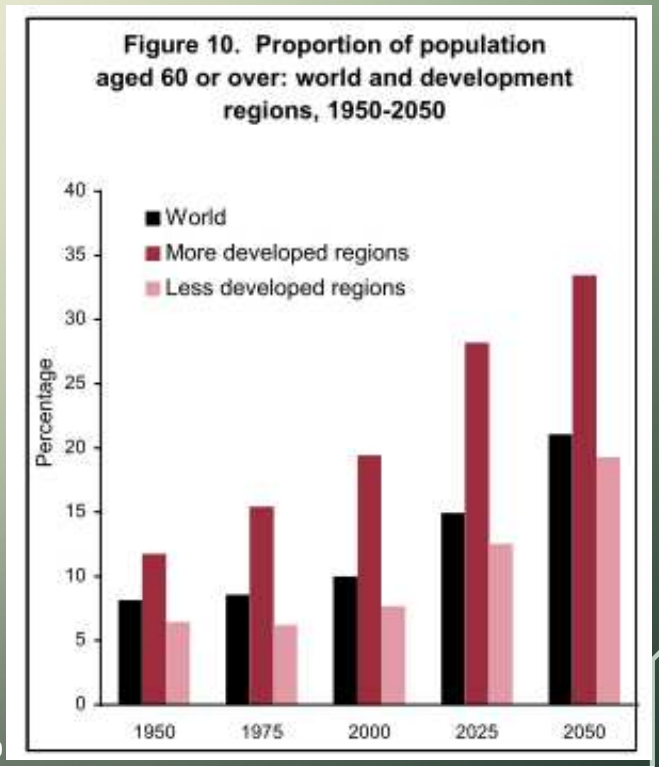
EU-IST funded Amigo project (video)

IMPORTANCE

- In 2050 37% of EU inhabitants (20% in the world) will have more then 60 years, and ratio between 65 years old person and an active one will bellow one. This is why will be a huge demands on nurses/care givers.
- By 2030, 1 in 5 Americans will be age 65 or older
  - Average life expectancy 81 years
  - By 2040: Alzheimer related costs will be 2 trillion dollars



UN Report, Department of Economic and Social Affairs, Population Division , 2001
http://www.un.org/esa/population/publications/worldageing19502050/

IMPORTANCE

Facts

- 8.5 million seniors require some form of assistive care
  - 80% of those over 65 are living with at least one chronic disease
  - Every 69 seconds someone in America develops Alzheimer's disease

Costs

- Alzheimer's Disease: $18,500-$36,000
- Nursing home care costs: $70,000-80,000 annually
- Annual loss to employers: $33 billion due to working family care givers

Caregiver gap

- Nurses shortage: 120,000 and 159,300 doctors by 2025
- Understaffed nursing homes: 91%
- Family caregivers in US: 31% of households
  - 70% of caregivers care for someone over age 50

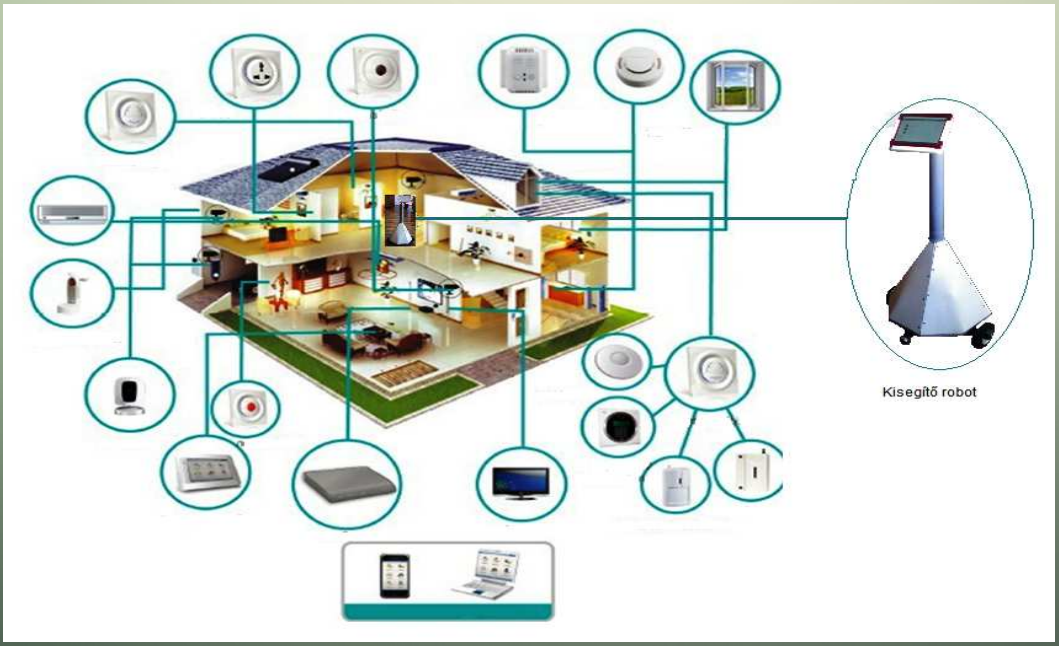
Statistics from http://www.hoaloharobotics.com/

OLDER ADULTS CHALLENGES

- Normal age related challenges
  - Physical limitations
    - Balance, reaching, etc.
  - Perceptual
    - Vision, hearing
  - Cognitive
    - Memory, parallel tasks
- Chronic age related diseases
  - Alzheimer's Disease (AD)

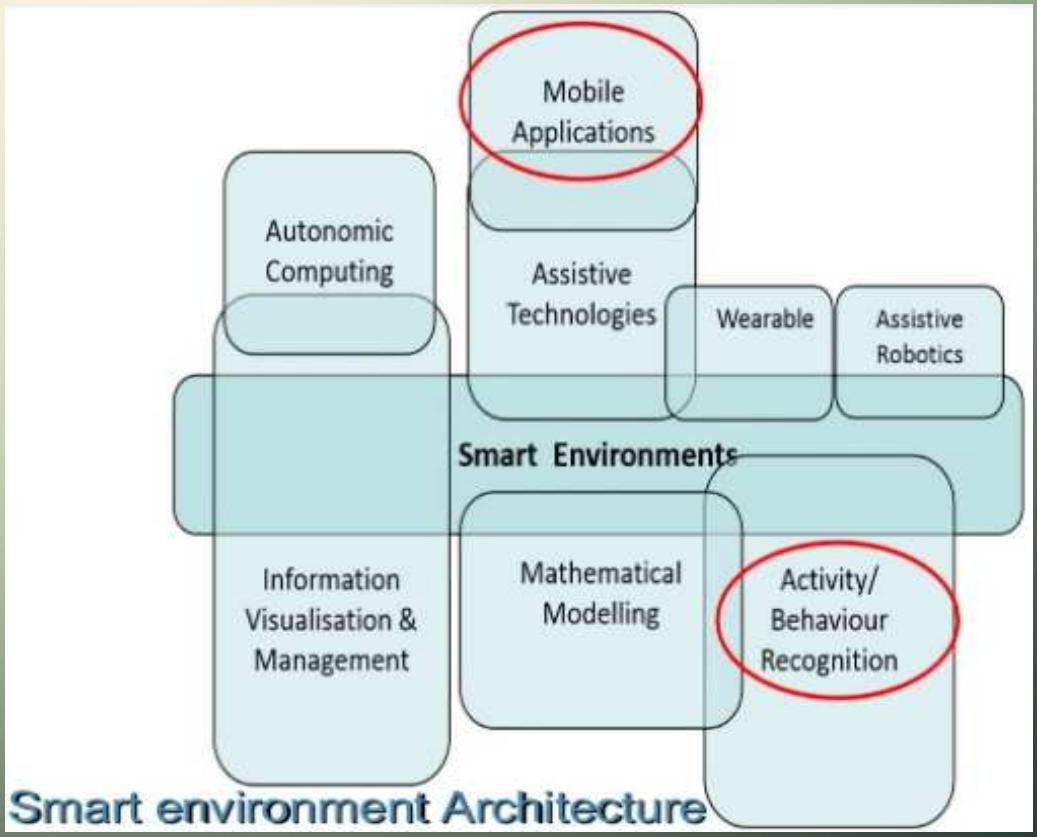
AMBIENT ASSISTED LIVING

- The lack of enough human caregivers, could be compensated with the home environment, and quality of life improvement: the widespread of the smart homes and use of assistive robots.
- The aim is to take advantage of living for as long as possible in familiar surrounding.
- The target is to link the smart home technologies with mobile assistive robots



SMART ENVIRONMENT ARCHITECTURE

Smart homes
Mobile devices
Wearable sensors
Assistive robotics



SMART ENVIRONMENT ARCHITECTURE

Examples (ambient, wireless)

Examples (wearable)

Metria™ Informed Health
3-axis accelerometer, Galvanic Skin Response,
2 temperature sensors (body, skin)

Self-tracking
Steps, calories, sleep, distance, ...

http://www.notchdevice.com/
Inside clothes
Haptic Feedback
Movement capture

SMART HOMES AND INTELLIGENT ASSISTIVE TECHNOLOGIES

- The smart home is a home/building that has a lot of sensors, actuators, electronic and automation devices connected to the internet.
- These allow assisted living, remote monitoring, early detection of emergency cases and generally improvement of quality of life.
- " Intelligent assistive technologies " are information and communication technologies that allow the independent living in the preferred environment.
- In this way the system is patient centered, rather than institution centered, because it is designed to meet the needs of individuals, their families and caregivers.
- AAL: Ambient Assisted Living
  - Assisted Living + Ambient Intelligence
- Gerontechnology
  - Gerontology + Technology

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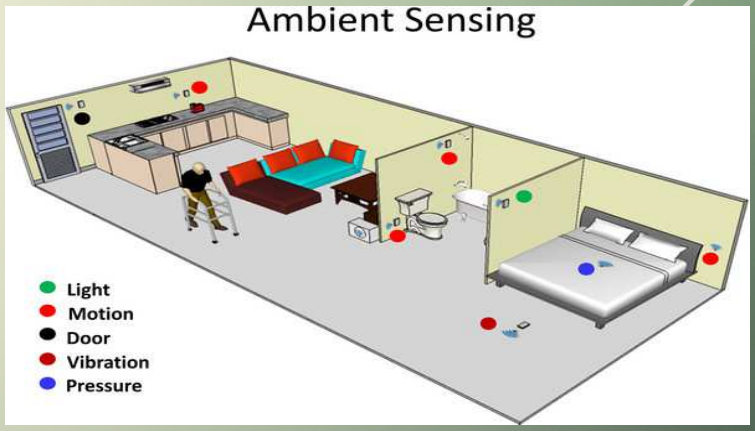
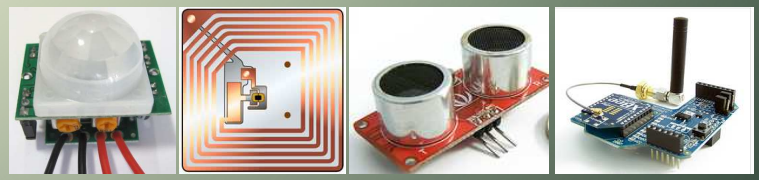
SMART HOMES

- Sensors & actuators integrated into everyday objects
  - Ambient parameters monitoring modules
  - PIR (Passive Infrared Sensor)
  - RFID
  - Ultrasonic
  - Pressure sensors (in beds, floor)
  - Contact switch sensors
  - Gas sensors

- Knowledge acquisition about inhabitant

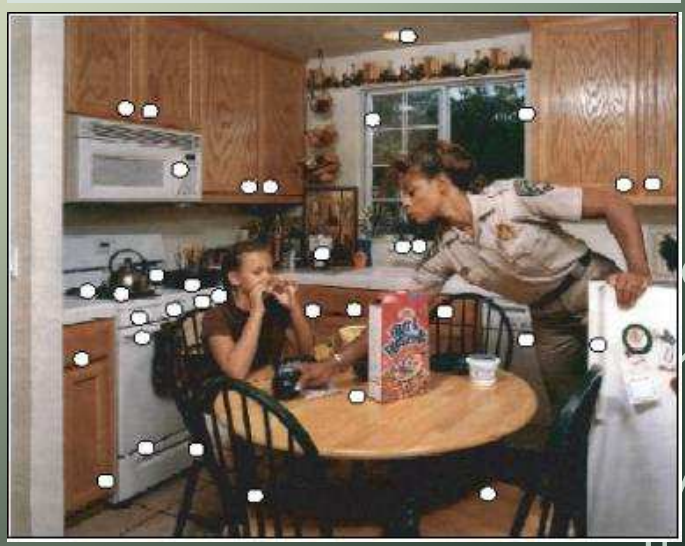




SMART HOMES EXAMPLES

* US
  * Aging in Place, TigerPlace (U. of Missouri), Aware Home (Georgia Tech), CASAS (Washington State U.), House_n (MIT)
* Asia
  * Welfare Techno House (Japan), Ubiquitous Home (Japan)
* Europe
  * iDorm (University of Essex), HIS (France)

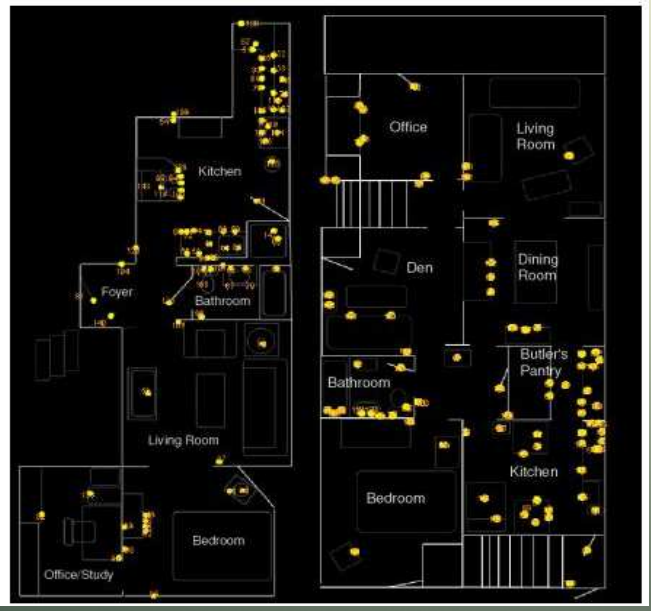
CASAS, WSU



MIT: ACTIVITY RECOGNITION IN THE HOME SETTING

- Two single-person apartments collecting data from 77 / 84 sensor boards equipped with reed switch sensors
- Running different algorithms to recognize activities
- Cluster the sensor activations to predict possible activities
- Measure changes of human behavior from day to day

- 77 in home 1
- 84 in home 2

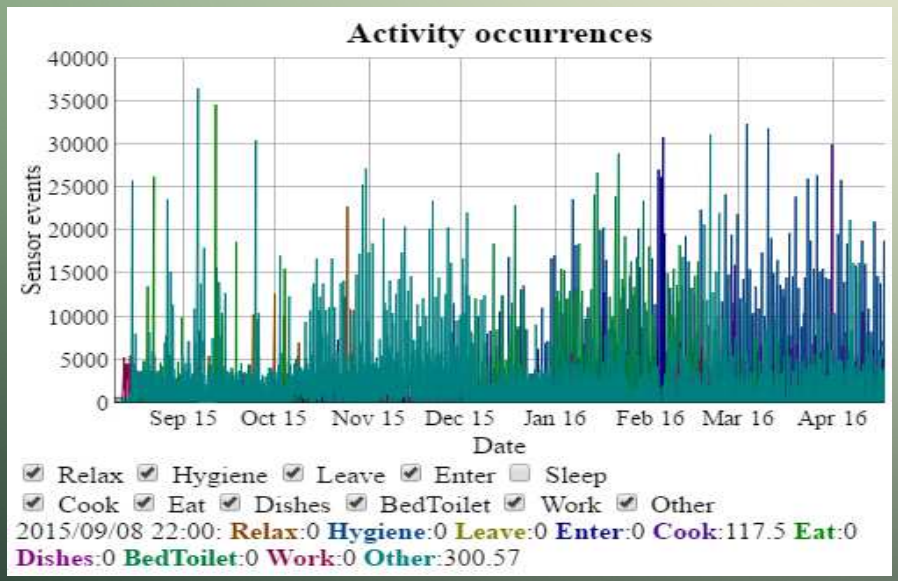


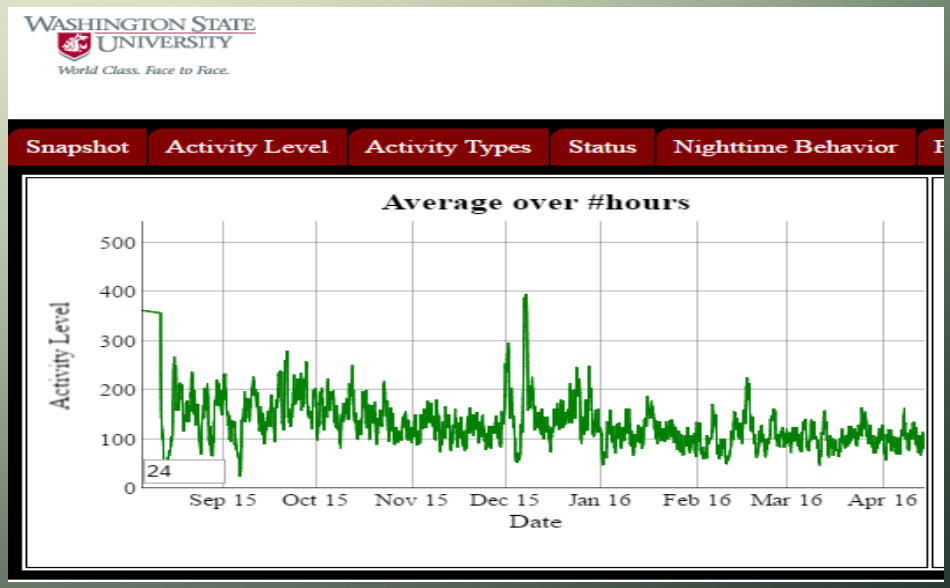
Number of Examples per Class		
Activity	Subject 1	Subject 2
Preparing dinner	8	14
Preparing lunch	17	20
Listening to music	-	18
Taking medication	-	14
Toileting	85	40
Preparing breakfast	14	18
Washing dishes	7	21
Preparing a snack	14	16
Watching TV	-	15
Bathing	18	-
Going out to work	12	-
Dressing	24	-
Grooming	37	-
Preparing a beverage	15	-
Doing laundry	19	-
cleaning	8	-

MY HOUSE

http://ailab.wsu.edu/casas/hh/shib011/profile/page-1.html

1	SHiB server (This is the mini-computer that store and communicate sensor data.)
3	Relay
24	Infrared sensor (**Front** and **back door; Bedroom** A/B/C Bed/Door/Area; **Kitchen** Sink, Stove, Refrigerator; etc.)
2	Temperature sensor
1	Magnetic door sensor





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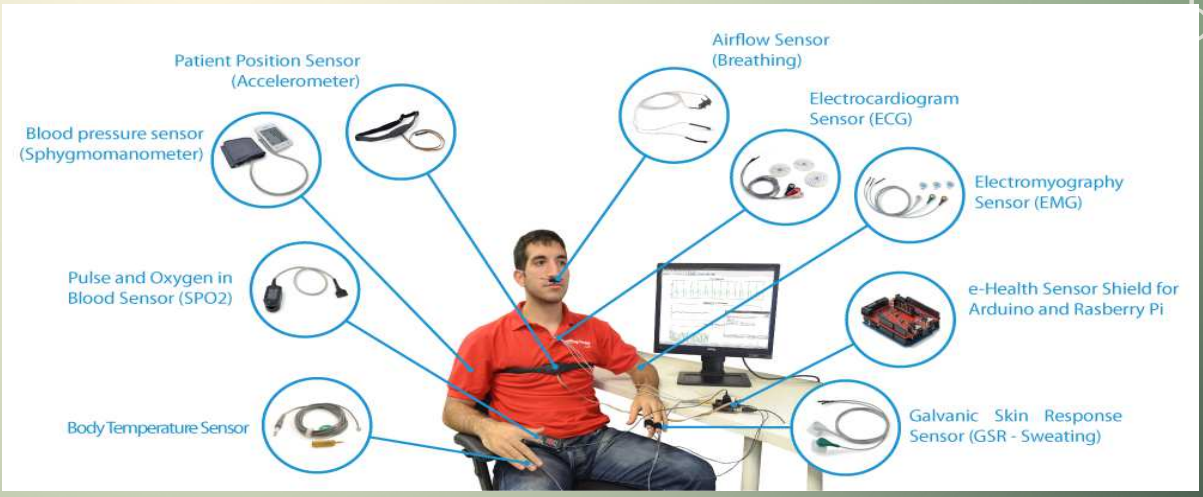
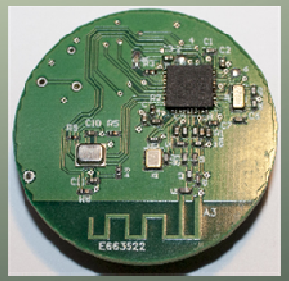
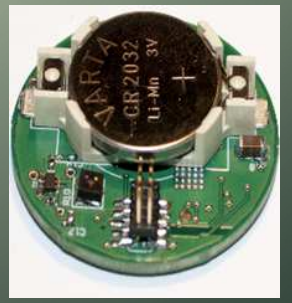
WEARABLE DEVICES

- Physiological parameters monitoring- sensors
  - Temperature sensors
  - Respiration sensors
  - Galvanic Skin Response (GSR)
  - Blood pressure
  - Heart rate
  - ECG devices
  - EMG device
  - EEG device
  - Pulse Oximeter
- Movement (activity, falling detection)
  - 9 (6) DOF IMU
    - Accelerometer (3 axes)
    - Gyroscope (3 axes)
    - Magnetometer (3 axes)

e-Health Sensor Platform V2.0 by Cooking-Hacks

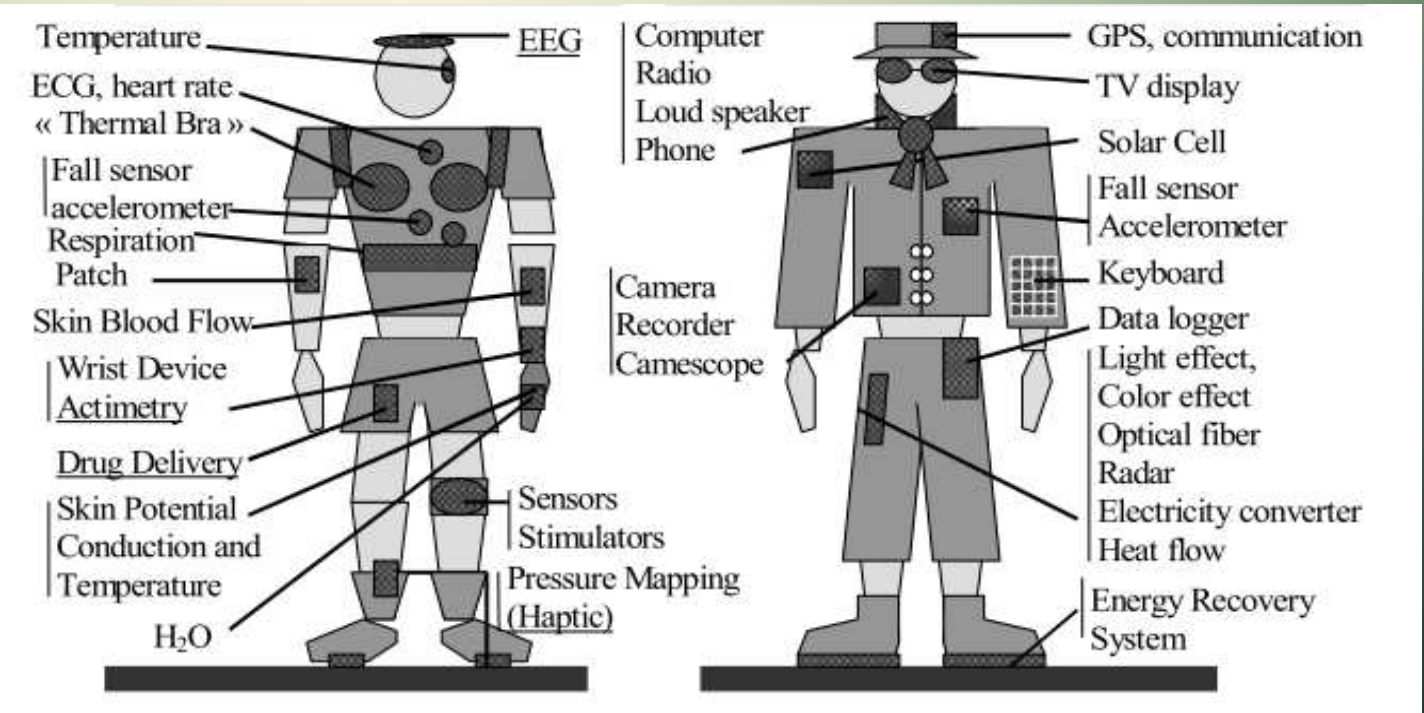






SENSORS PLACEMENT

- Close to the skin
  - Biomedical purpose
- In pocket or small bags
  - Data acquisition
  - Processing
  - Communication



*A. Dittmar; R. Meffre; F. De Oliveira; C. Gehin; G. Delhomme; , "Wearable Medical Devices Using Textile and Flexible Technologies for Ambulatory Monitoring," *Engineering in Medicine and Biology Society, 2005. IEEE-EMBS 2005.* , vol., no., pp.7161-7164, 2005

DATA TRANSFER

Sensors on body + a handheld or wearable data hub to communicate data wirelessly + a central node to process data

- Bluetooth (LE)
- ZigBee
- Proprietary protocols (Bluerobin, SimplyciTI, etc.)
- WIFI
- 3G/GPRS

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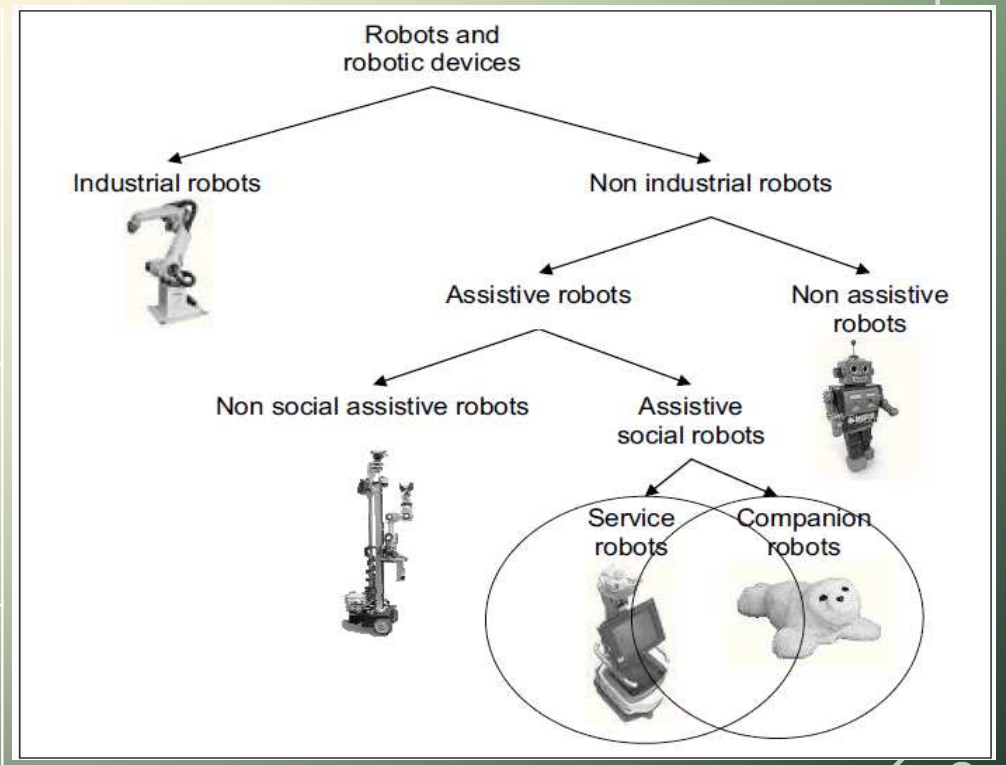
ASSISTIVE ROBOTS - CLASSIFICATION

Personal assistance robots	• Rehabilitation robots • Wheelchair robots • Companion robots • Manipulators for physically disabled • Educational robots • Robots for some kind of interaction
Users	• Elderly • Physical impaired person • Persons with cognitive disorders • Students, children
Tasks	• Everyday life support • Assess functional capacity exercise for function development • Communication support • Education



Assessing acceptance of assistive social robots by aging adults - Author M. Heerink

OVERVIEW OF ASSISTIVE ROBOTS (1)

Almost all major universities and research centers have research related to health care and quality of life, including home care robots.

- Georgia Tech – Cody robot;
- Carnegie Mellon University. – Herb robot;
- Fraunhofer Institute - Care-O-Bot;
- Yale, University of Southern California, MIT - Socially Assistive Robotics project;
- CIR and KAIST (Korea) - own developed robot.

From Left: AnyBots QB, RoboDynamics TiLR, Gostai Jazz Connect, Mantaro's Mantaro Bot, and VGo

Bot:	QB	TiLR	Jazz Connect	Mantaro Bot	VGo
Manufacturer:	AnyBots	RoboDynamics	Gostai	Mantaro	VGo
Availability Date:	March 2011	Summer 2008	January 2011	March 2011	November 2010
Price Tag & Per Month Charges if any:	$15,000 / $0	$10,000 /$0-$100/mo/user	$11,000 / $0	$3,500 / $0	$5,995 / $100
Height & Weight:	Height Adjusts: 30-74" 35 lbs	42" and 48" 60lbs	40" / 18lbs	63" / 40 lbs 15.5" x 15.5" footprint	48" tall, 13"x15" footprint / 18 lbs
Top Speed:	5.13 feet/sec	3.5 feet/sec	3.65 feet/sec	2.05 feet/sec	2.5 feet/sec

OVERVIEW OF ASSISTIVE ROBOTS (2)

RP-Robots - iRobot and InTouch Health common developments


iRobot Ava


RP-VITA


RP-7i


RP-LITE


RP-VENTAGE

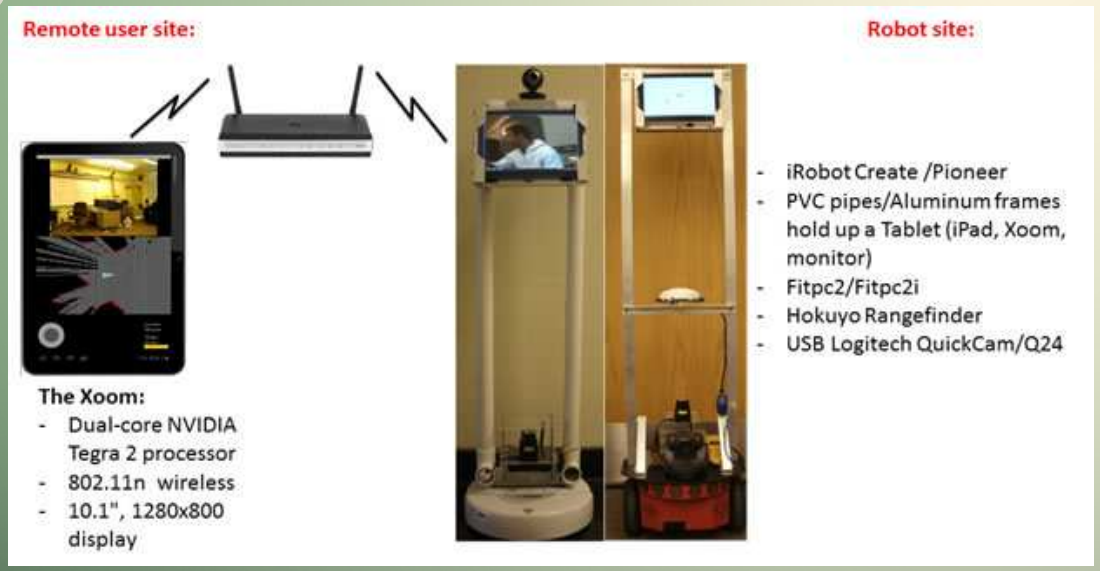

RP-XPRESS

Beam Remote Presence System (RPS)

Willow Garage

Suitable Technologies division of Willow Garage research labs

OPEN PLATFORM TELEPRESENCE ROBOTS



An Open Platform Telepresence Robot with Natural Human Interface, Laboratory for Advanced Sensing, Computation and Control , School of Electrical and Computer Engineering, Oklahoma State University

Willow Garage – TurtleBot (1 / 2)

- iRobot Create / Kobuki Base
- 3D Sensor - Microsoft Kinect
- ASUS 1215N netbook
- ROS

UNIDEB PATHFINDER ZYBOT

- Roomba iRobot platform
- Digilent ZYBO FPGA board with dual core ARM processor
- Xilinx Vivado, Xilinx SDK
- Linux OS
- 6 ultrasonic range finder
- 3 axis digital compass
- Wifi module
- RFID reader
- USB camera
- Bluetooth module
- Accumulator
- DC-DC converter
- Android smartphone for video stream

AUTHORS:
- József Zákány
- András Erdős

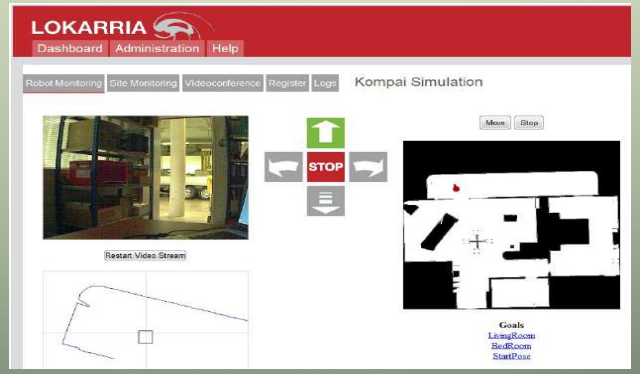
(TELE) ASSISTANCE ROBOT NEEDED FEATURES

General features

- Verbal contact between human and robot, cognitive support
- Patient monitoring
- Daily agenda
- Monitoring of physiological parameters
- Monitoring and emergency calls in case of alarms

Graphical user interface

- Accumulator state
- Internet connection
- E-mail
- Video call
- Web browser
- Shopping list
- Weather forecast
- Agenda
- Games
- Medication remainder
- Robot navigation



[7] Local and remote application interfaces DOMEO project A. Lago, DOMEO, Domestic Robot For Elderly Assistance. First Results and Perspectives, AAL Forum 2011, Lecce, Italy

OTHER ISSUES

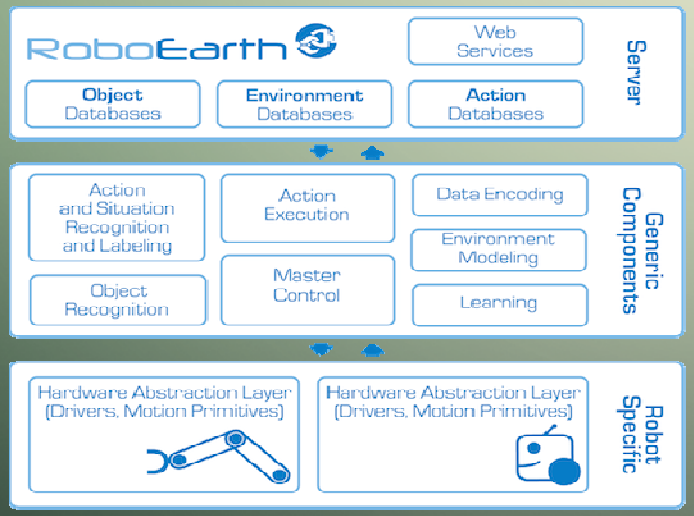
- Indoor localization
- Speech communication (speech recognition/synthesis)
- Patient activity pattern recognition by robot and adequate reaction

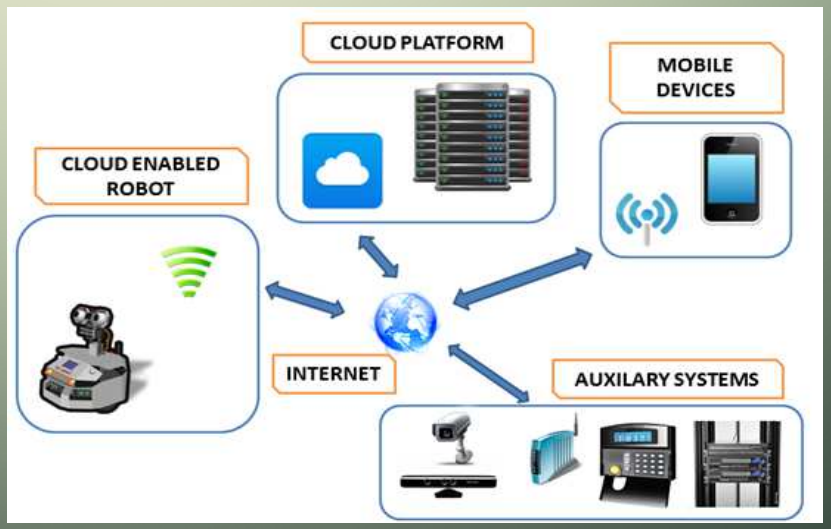
- **Softver platform for robots**
  - Microsoft® Robotics Studio
  - ROS (Robot Operating System)
  - RobuBOX - Software Development Kit (SDK) – open source
  - Urbi Open Source - Urbi new innovative, easy to use, powerful, universal robotic software platform
  - Gostai Suite - complete IDE

CLOUD FOR ROBOTS

James Kuffner, assoc. prof. at Robotics Institute in Carnegie Mellon University member of the Google Car Project – has contributed to this concept

A RoboEarth Cloud Engine RoboEarth – EU project leaded by Eindhoven University of Technology, aiming to develop "World Wide Web for robots". This is a huge database, used by robots for changing information about things, ambient and tasks





HOME'S INTELLIGENT PERSONAL ASSISTANT

- is a software agent that can perform tasks or services for an individual
- the capability and usage of virtual assistants is expanding at an exponential rate
- the most widely used being:
  - Amazon Alexa,
  - Google Assistant,
  - Microsoft Cortana,
  - Apple's Siri.

HOME'S INTELLIGENT PERSONAL ASSISTANT

Virtual assistants may be integrated into many types of platforms:

- Into objects like smart speakers such as Amazon Echo and Google Home
- In instant messaging apps on both smartphones and via the Web, e.g. Facebook's M (virtual assistant)
- Built into a mobile operating system (OS), as are Apple's Siri on iOS devices, or into a desktop OS such as Cortana on Microsoft Windows OS
- Built into a smartphone independent of the OS, as is Samsung Bixby on the Samsung Galaxy S8, and Google Assistant on the Google Pixel.
- On other mobile apps such as Google Allo
- On smartwatches, In appliances, cars, and Android Wear clothing.

HOME'S INTELLIGENT PERSONAL ASSISTANT

Services

- Provide information such as weather, facts from e.g. Wikipedia or IMDB, set an alarm, to-do lists, shopping lists,
- Play music from streaming services such as Spotify and Pandora; play radio stations; read audiobooks
- Play videos, TV shows or movies on televisions, streaming from e.g. Netflix
- Buy items from e.g. Amazon

1. What can you do?
2. When's my first event tomorrow?
3. Turn your volume to 7.
4. Repeat that.
5. Wake me up at 6AM.
6. Tell me about my day.
7. How long will it take me to get to work?
8. How long will it take to get to McDonald's?
9. What does circumlocution mean?
10. How many calories in a apple?
11. How many calories in a burrito from Cafe Rio?
12. Who won the BYU game?
13. How is the S&P 500 doing?
14. How is GoPro's stock?
15. Spell Pterodactyl
16. How do I say "More Please" in Spanish?
17. What is 10 x 10?
18. How many species of tiger are there?
19. Where is the nearest pharmacy?
20. What is their phone number?

GOOGLE HOME

- is a smart speaker developed by Google. It was released in the United States in November 2016, and in the United Kingdom in April 2017, followed by Australia, Canada, France, Germany, and Japan in summer 2017.

- Google Home enables users to speak voice commands to interact with services through the Home's intelligent personal assistant called Google Assistant.
- Assistant is able to engage in two-way conversations with users
- Google Home includes home automation features, enabling owners to use it as a central hub to control smart devices. Examples of supported devices include the Chromecast digital media player, and products from Nest, SmartThings, Philips Hue, and Logitech Harmony

AMAZON ECHO AND ECHO DOT

- Amazon Echo is a smart speaker developed by Amazon.com.
- The device consists of a cylinder speaker with a seven-piece microphone array.
- The device connects to the voice-controlled intelligent personal assistant service Alexa, which responds to the name "Alexa".

GOOGLE HOME VS AMAZON ECHO!

Google Home Vs Amazon Echo Review

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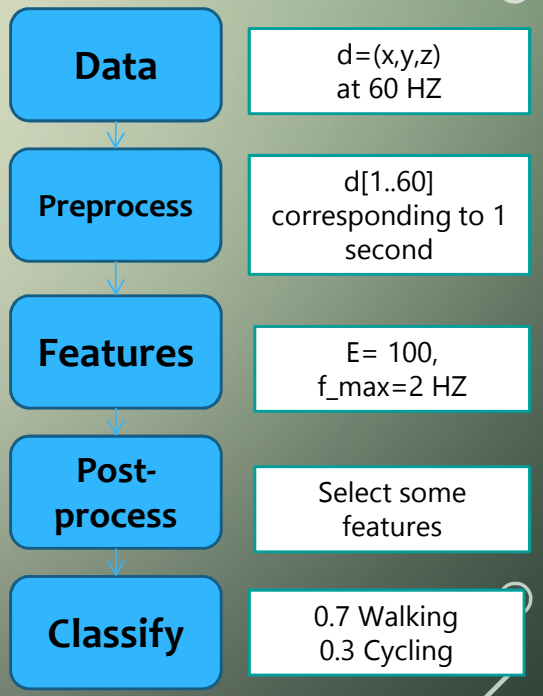
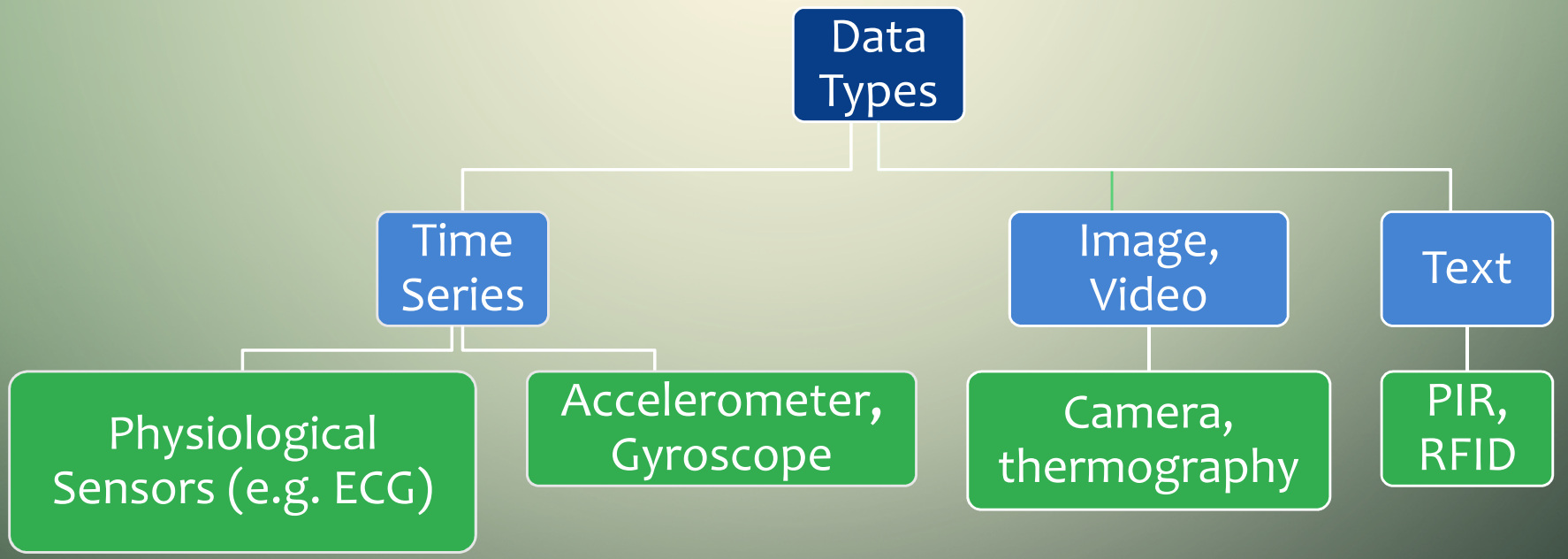
SIGNAL ACQUISITION, FILTERING, PROCESSING AND RECOGNITION

- Activity detection based on acceleration:
  - activity types: running, walking, sitting, standing, falling, other
  - data acquisition
  - preprocess
  - features extraction from acceleration signal:
    - minimum, maximum, average, deviation, correlation, covariance, energy, entropy
  - feature selection
  - recognition of current activity (with the trained neural network)
- Sensorial data fusion:
  - combine different sensorial information in order to identify the state of a patient (temperature, acceleration, ECG, heart rate)



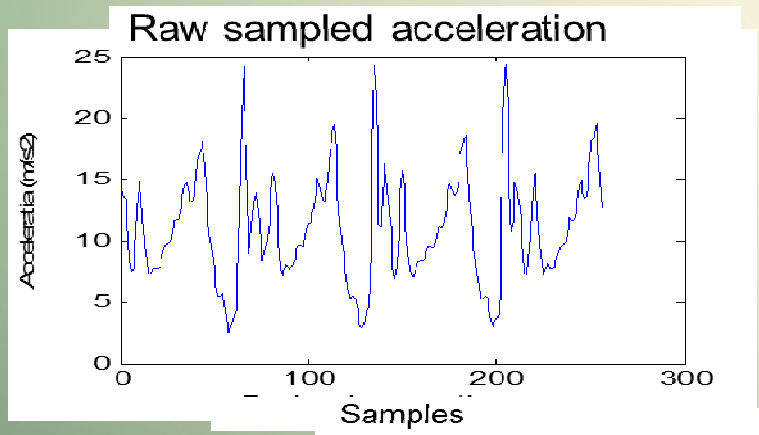
DATA SOURCES

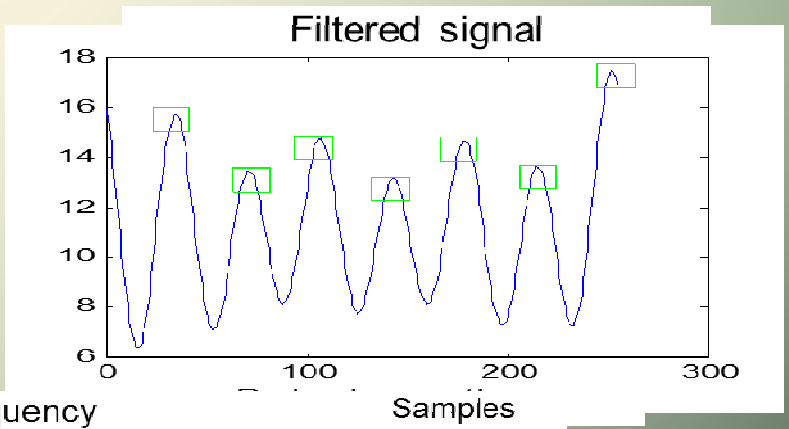


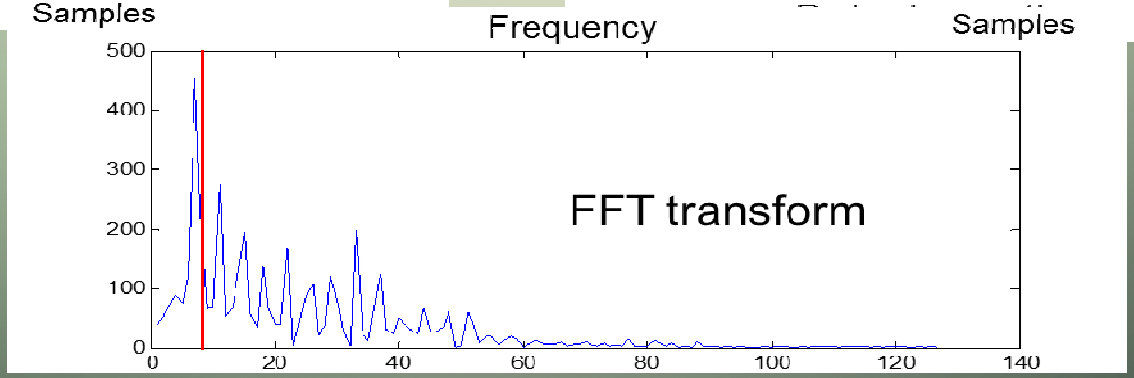
SENSORIAL DATA ACQUISITION

- Acceleration sensors
  - Can be used for activity detection:
    - running,
    - walking,
    - seating,
    - standing,
    - falling,
    - etc.

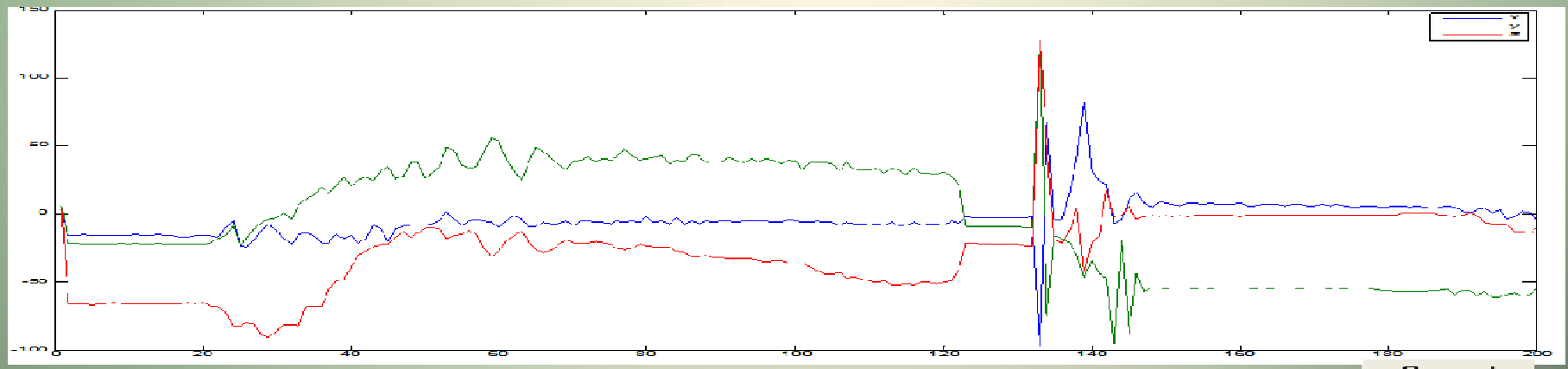
STEP RATE DETECTION AND COUNTING

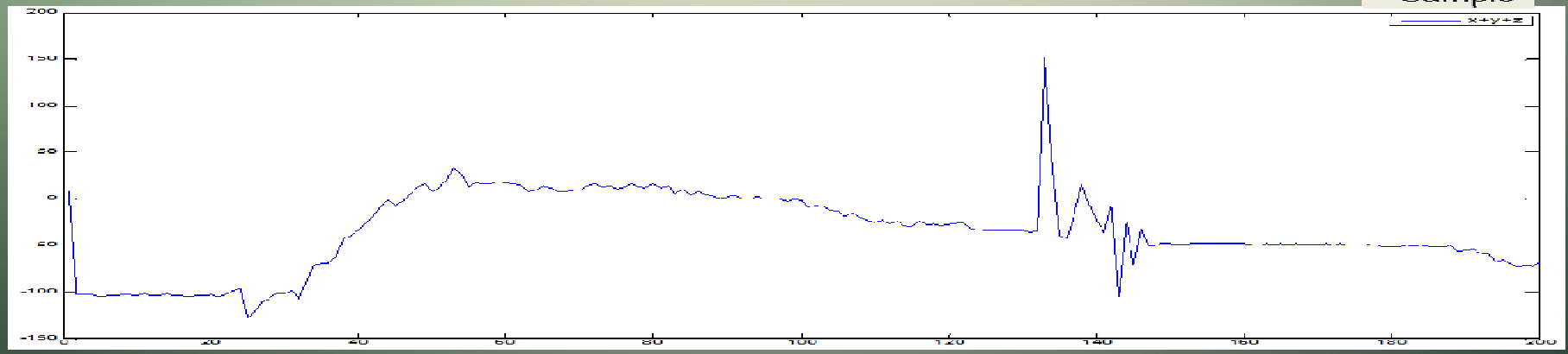






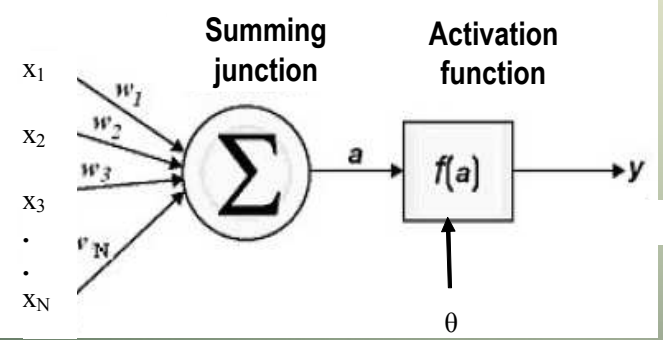
FALLING DETECTION





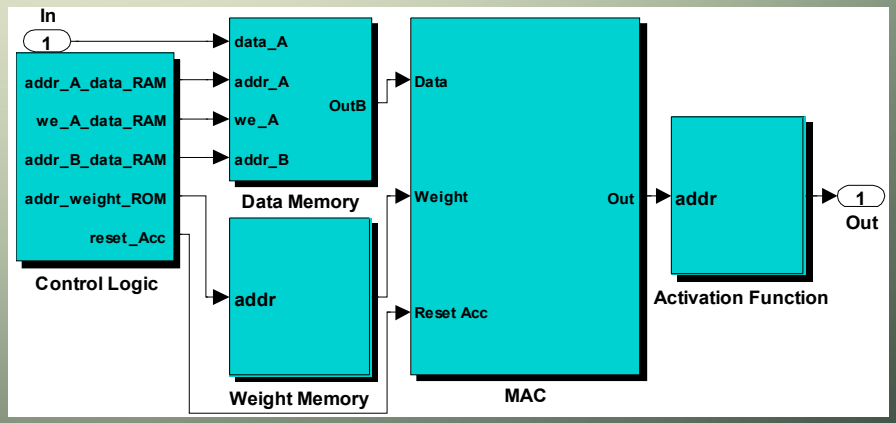
CLASSIFICATION USING ARTIFICIAL NEURAL NETWORKS

- The use of Neural networks is essential for learning capability and adaptive behavior of a system.
- An original method for hardware implementation of artificial neural networks (ANN) Using Xilinx System Generator extension for Simulink/Matlab .
- We have developed a library that can be used for rapid prototyping of ANNs.



$$y(x) = f(a-\theta) = f\left(\sum_{i=1}^{N} w_i x_i - \theta\right)$$

McCulloch-Pitts modell



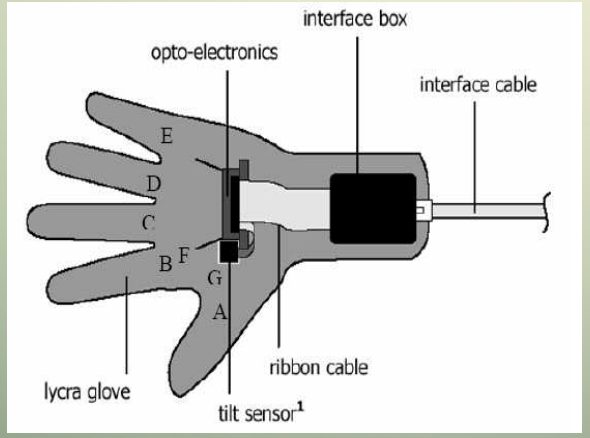
SUMMARY

- Ambient Intelligence
- AAL
  - Ambient systems
  - Wearable systems
  - **Assistive robots**
- Activity recognition
- Case studies

HAND GESTURE RECOGNITION SYSTEM

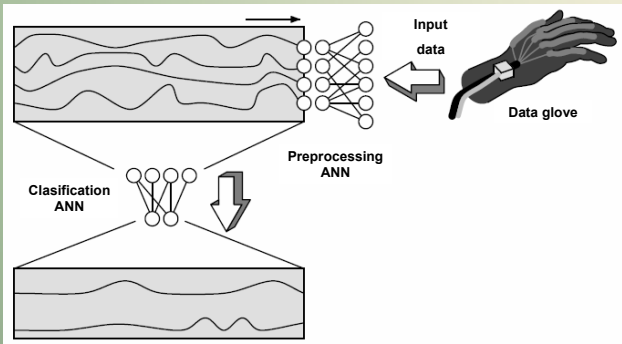
5DT- Sensorial Data glove

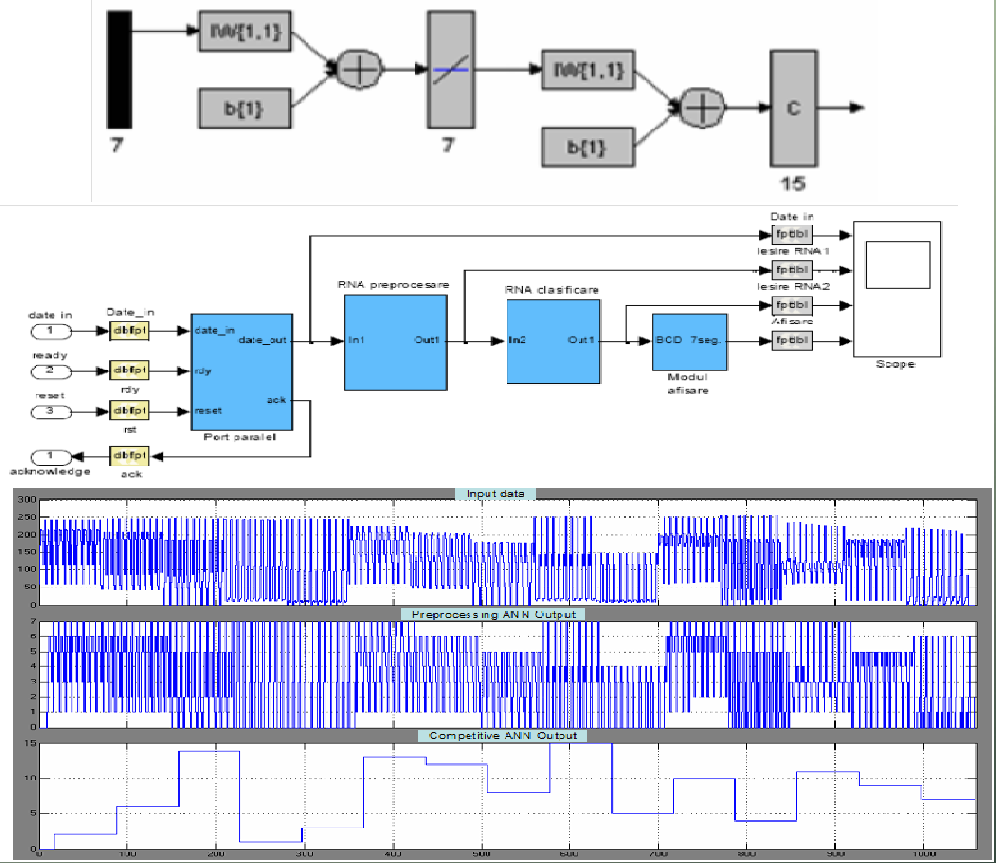
Figura 7.6 Mănușa 5DT- Data Glove 5



Gestures definition

HAND GESTURE RECOGNITION SYSTEM





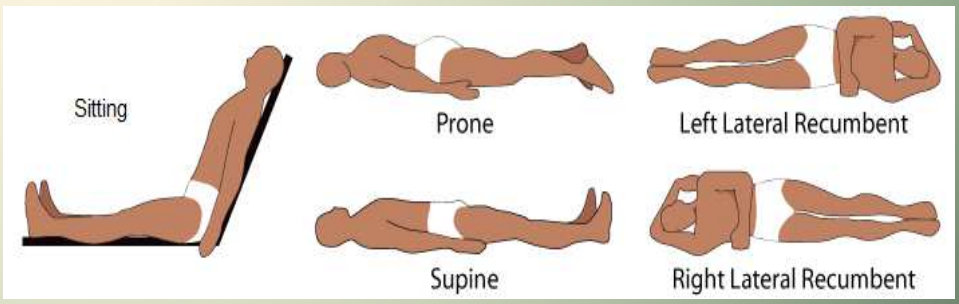
- ***two level architecture***
  - *Preprocessing FF NN*
  - *Gesture classifying NN*

Implemented function

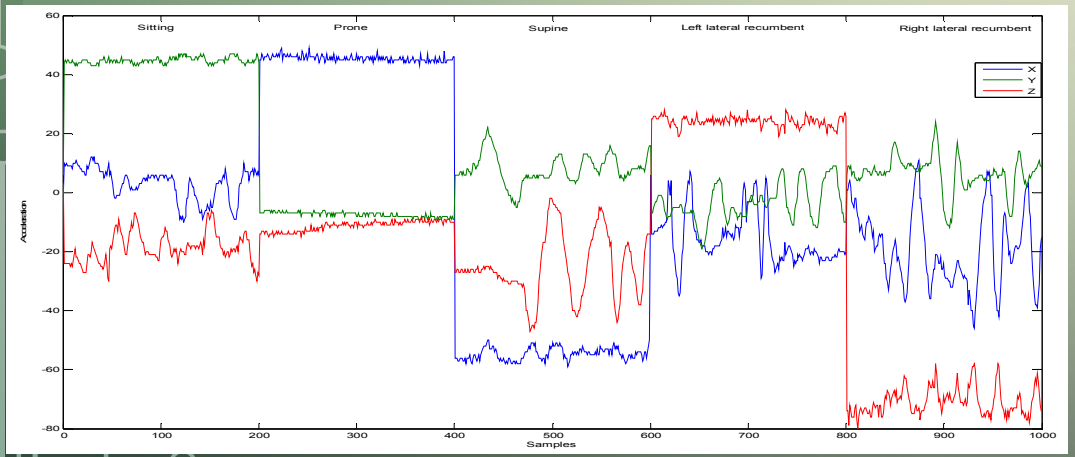
$$net_k = \sum_{j}^{N(1)} \left[\left(\sum_{i=1}^{M} w_i^{(1)} x_i^{(1)} - \theta \right) - w_{kj}^{(2)} \right]^2$$

BODY POSTURES RECOGNITION

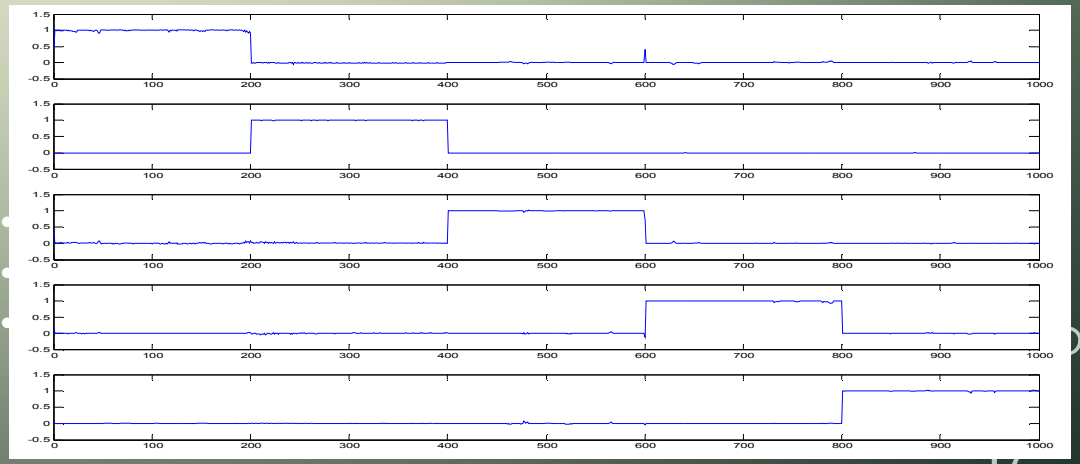
Body postures definition



Data aquired from acceleration sensor for the 5 body postures

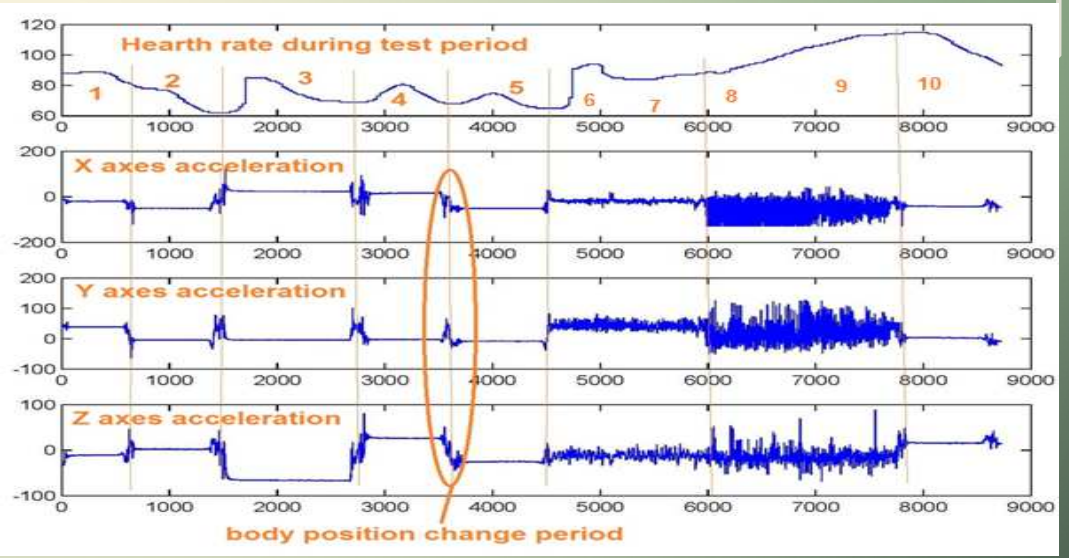


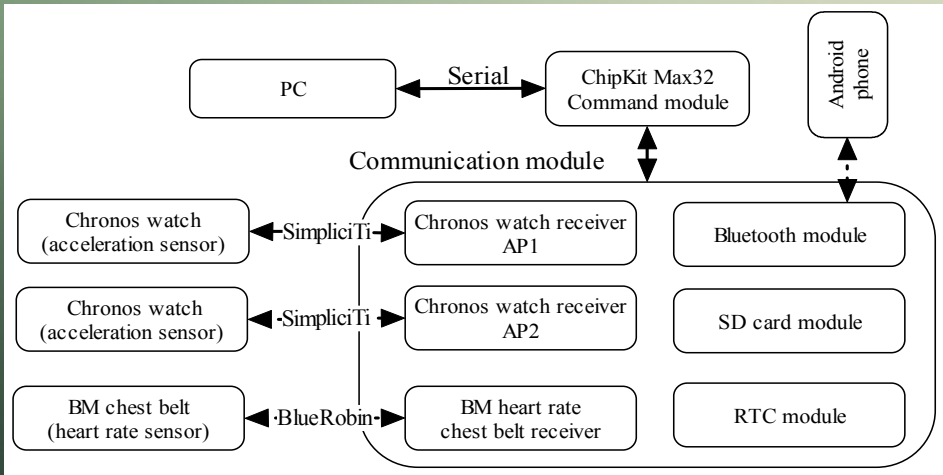
ANN ouput for the 5 body postures

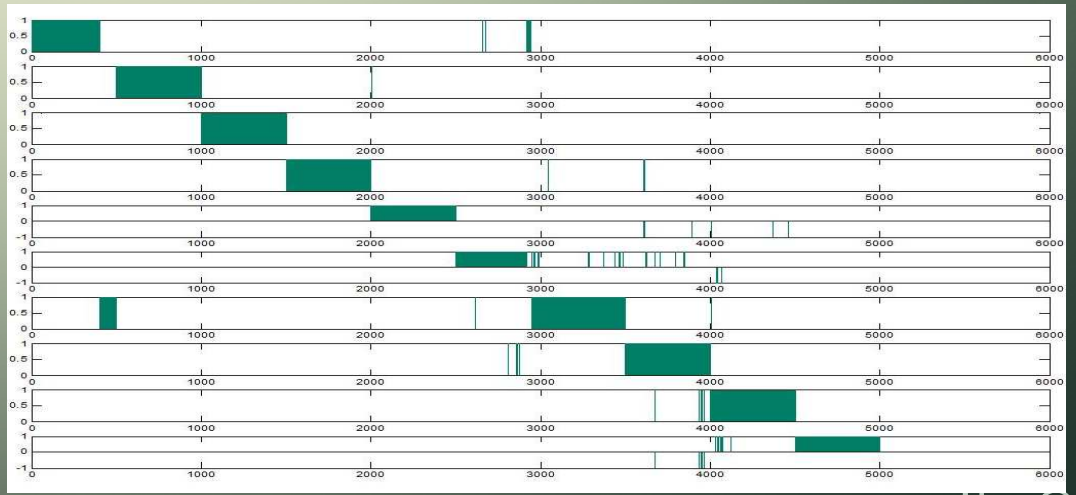


HUMAN ACTIVITY RECOGNITION

1. Standing
2. Supine
3. Left lateral recumbent
4. Right lateral recumbent
5. Prone
6. Walking (forward)
7. Walking (backward)
8. Running (forward)
9. Running(backward)
10. Seating

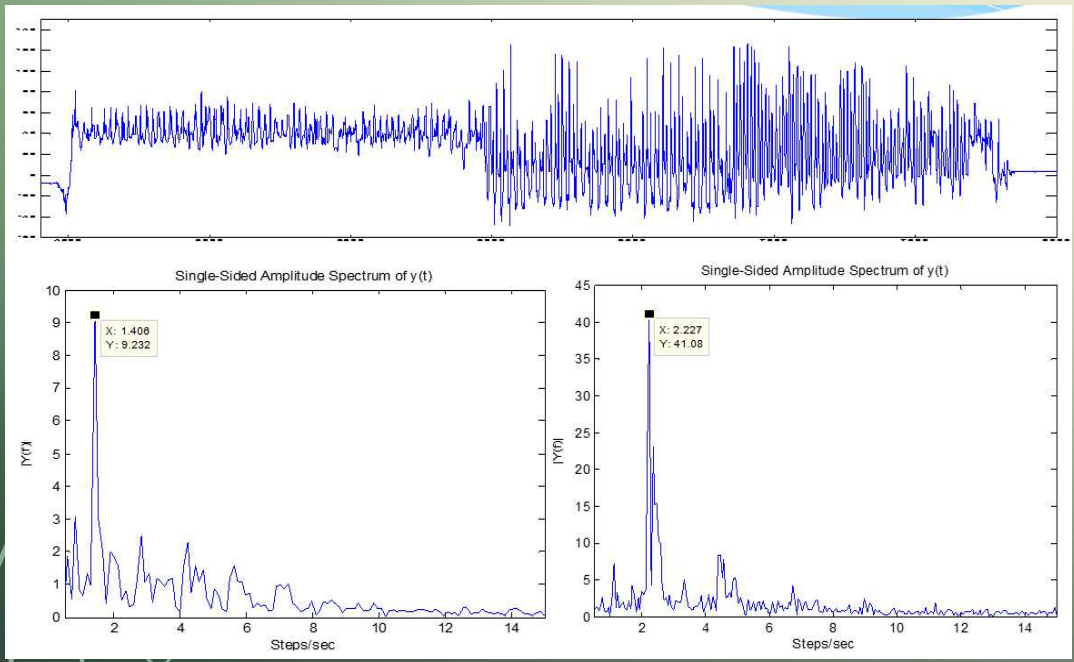


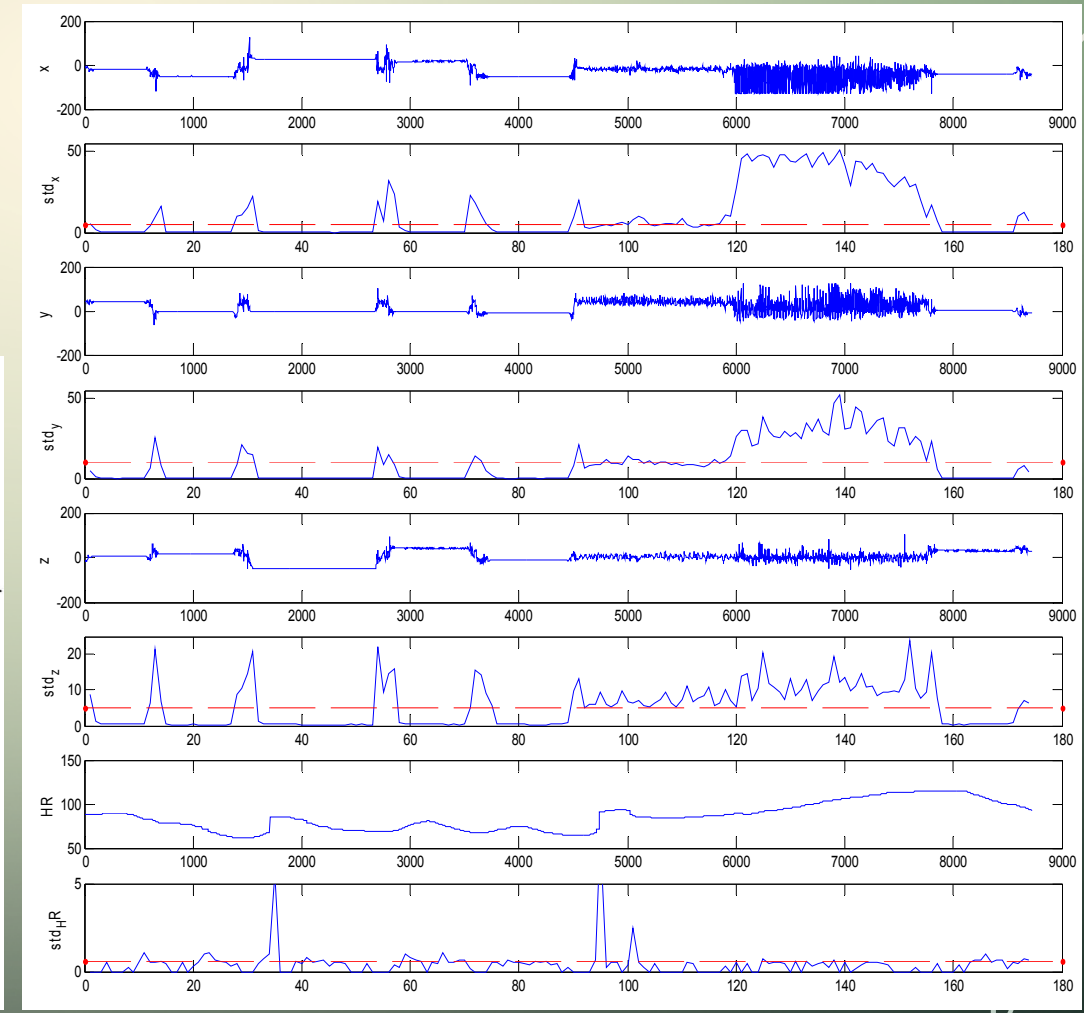




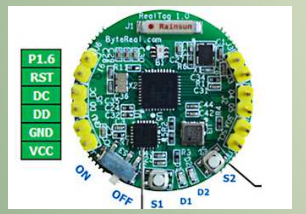
FURTHER RECOGNITION

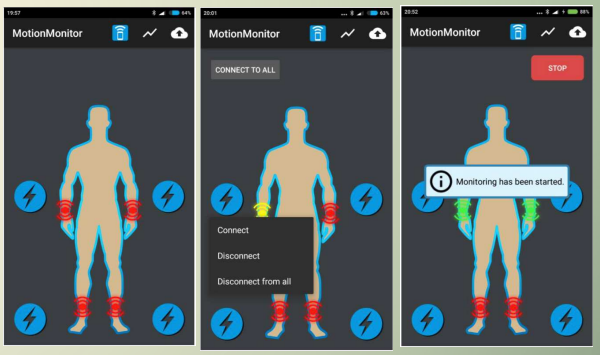
- Differentiating the dynamic activity from static
  - standard deviation
- Walking and running
  - FFT transform

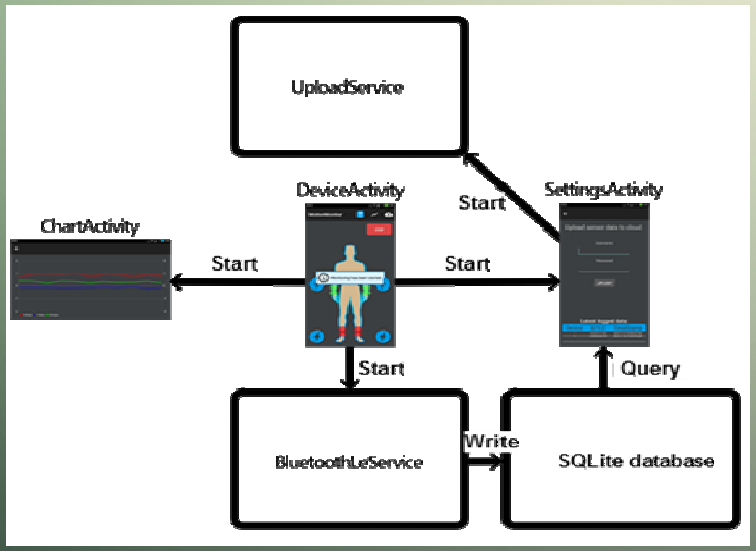


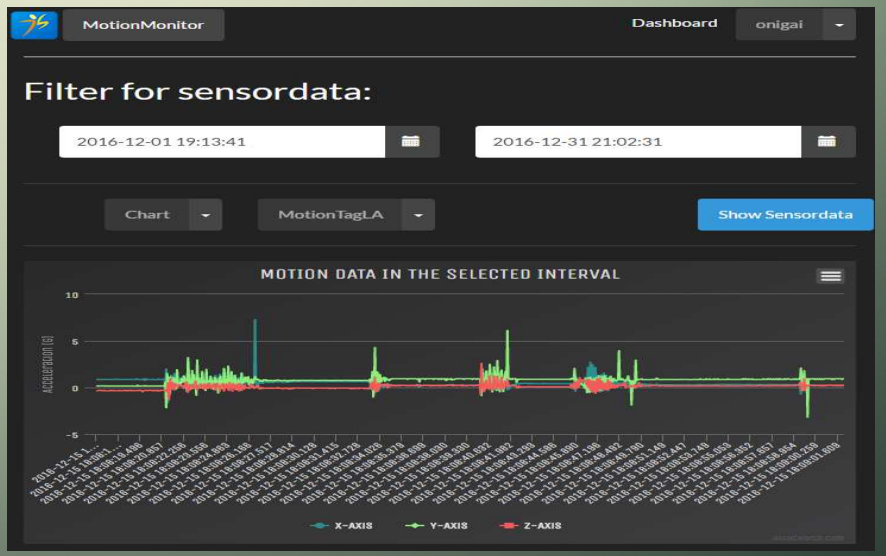


ACTIVITY RECOGNITION

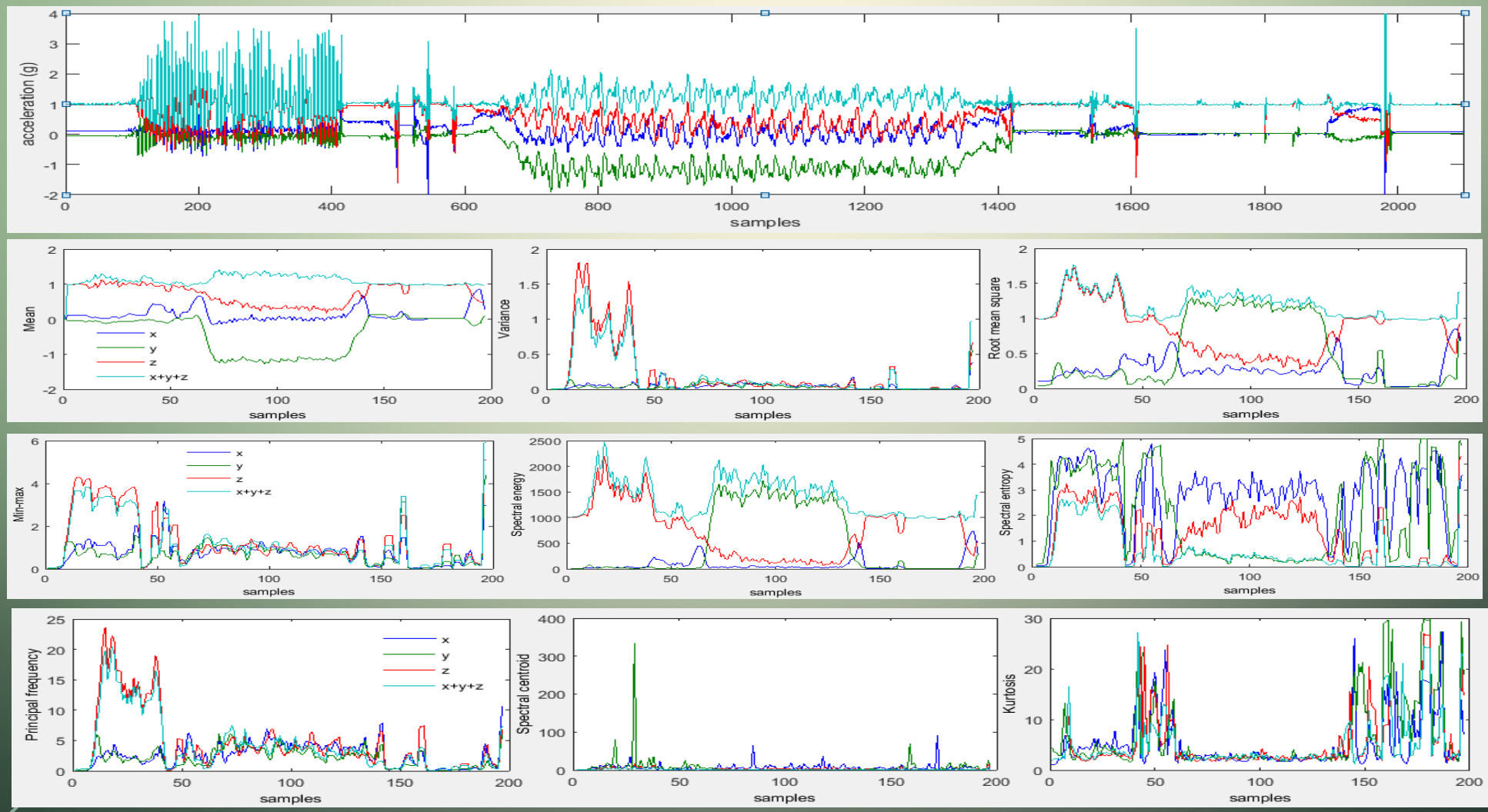








ACTIVITY RECOGNITION



OTHER ISSUES REGARDING AAL

- Learning capability and adaptive behavior
- Activity recognition
  - Feature extraction methods
  - Feature selection methods
  - Classification methods
- Ready to adopt? (Privacy Concerns)
  Big brother
  Stigmatization
- Wearable & mobile
  - Power harvesting
  - Size
- Assistive robotics
  - Marketing and price
  - Adaptive robots
- Legal & Ethical Challenges
  - Lack of regulations
    - Who is responsible for malpractice?
  - Insurance & reimbursement
  - Patient confidentiality
- Technology
  - Device interoperability
  - Integration of robots, smart home, wearable/mobile, sensors, e-textile

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