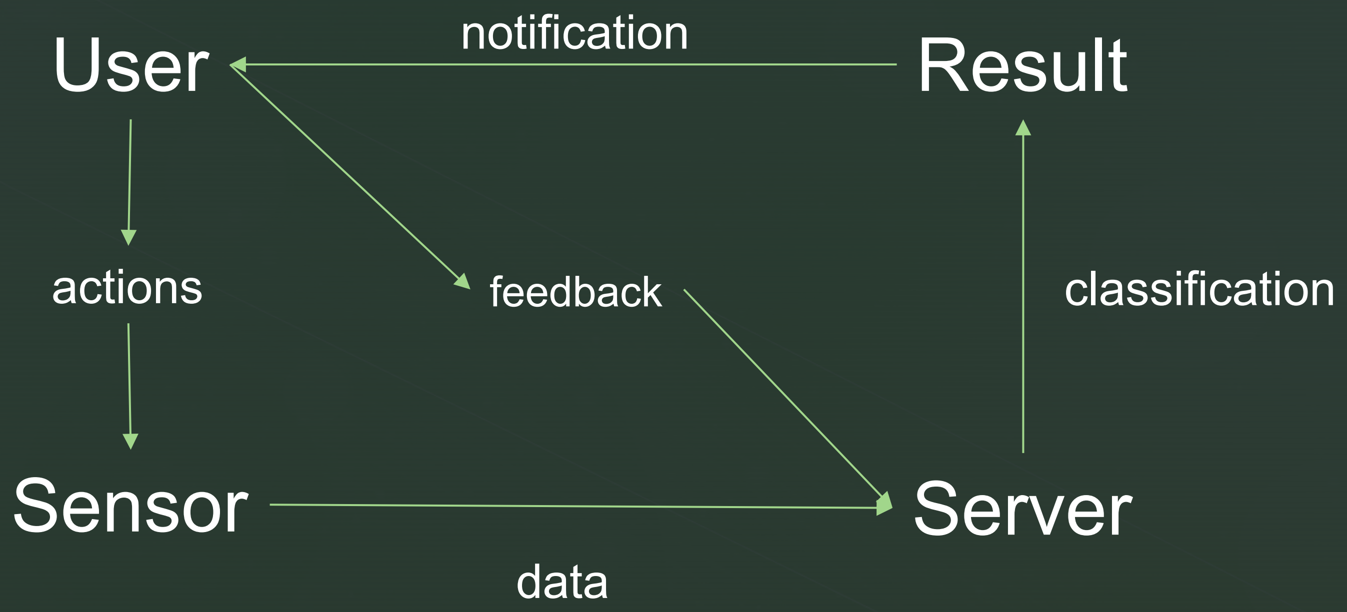
IoT sensing and building

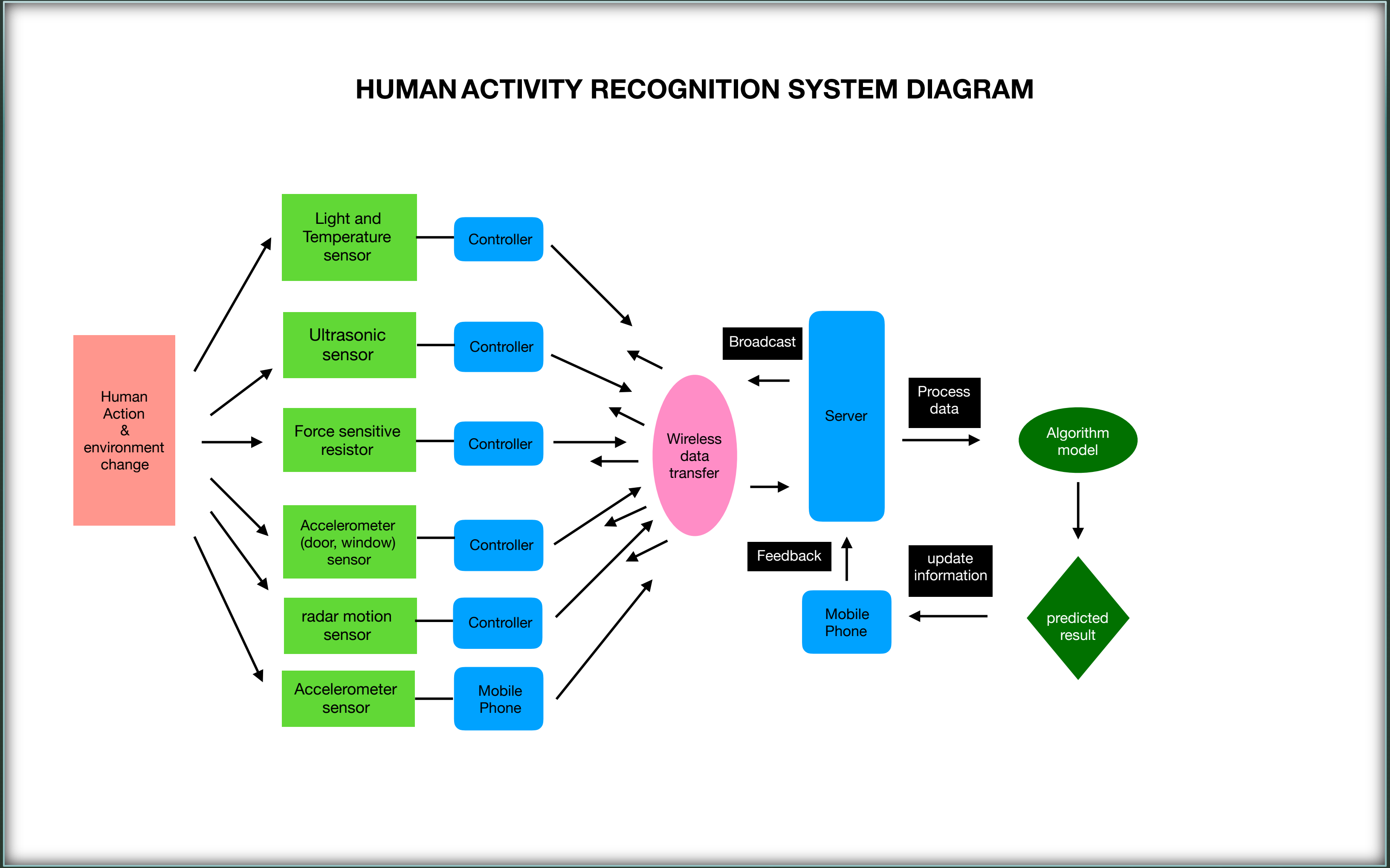
Sensor based Human Activity Recognition

- Aim: Recognize actions
- Targets:
  - Agents' actions
  - Environmental conditions
- Main methods:
  - A series of observations
  - sensor networks

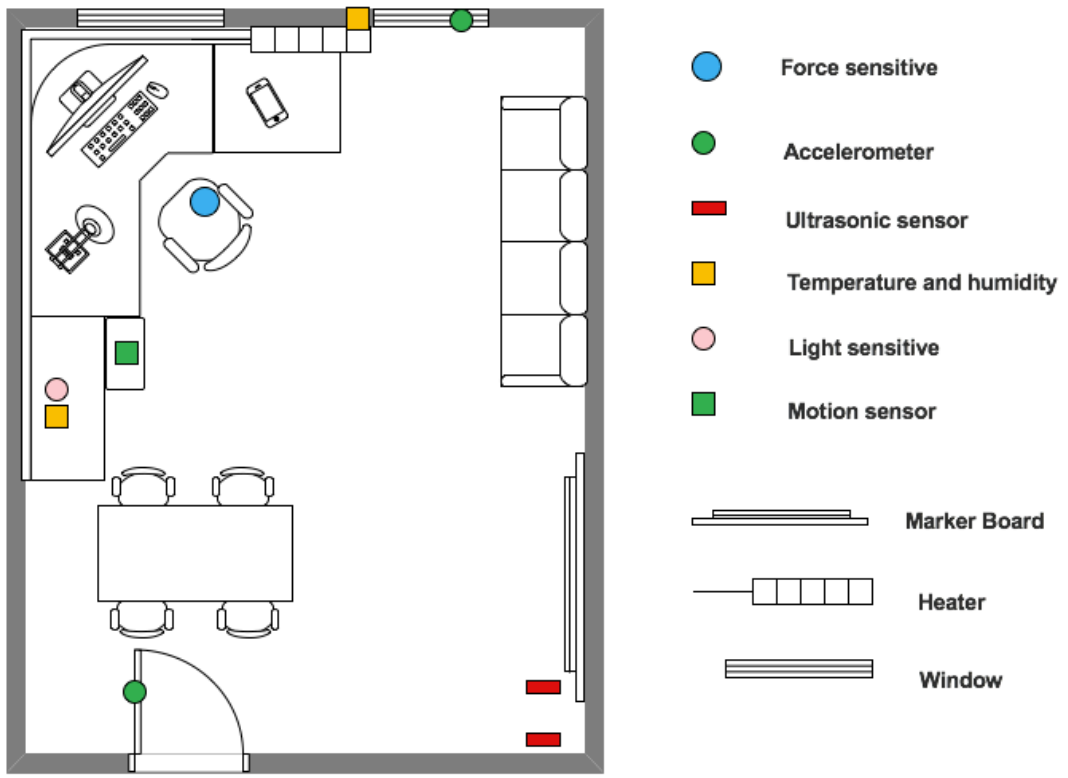
Interaction



System diagram



Sensor deployment



Data collection Server

Python & NodeJS server

Server programs run on Raspberry Pi

Python – Serial port

NodeJS – Bluetooth

Data collection Arduino

- Data was transmitted by a wireless Zigbee module (DL20)
- Data collection process

1. Arduinos wait for server's instructions
2. server emits a character
3. Arduinos receive the character and check
4. A certain Arduino responds to server with data.

Data collection Mobile

- Turn on Bluetooth service of iPhone
- Connecting to Raspberry pi server
- Send the accelerometer data

Machine Learning

- Labeling and Export
  - Assign specific activities to data sets by manually update data entries in database in selected time zones
- Noise Remove
  - Environmental noise and sensor noise
  - Implement filters and calibrate sensors
  - Assign specific activities to data sets by manually update data entries in database in selected time zones

Machine Learning

- Supervised Learning Methods
  - SVM:
    - 4 Models for each type of data(acc, sonar, motion and pressure)
    - Key parameters: C(regularization para), Kernel(RBF, LINEAR)
  - Decision Tree
    - Binary Tree
    - use optimized CART algorithm
    - Impurity measure: Gini index

Evaluation
SVM

BASIC KNOWLEDGE

Recall = TP/(TP+FN)

Precision = TP/(TP+FP)

$$f_\beta = (1+\beta^2)\frac{PR}{(\beta^2 P)+R}$$

Evaluation SVM

Accelerometer data

Before feature selection Features:[x,y,z]			
	SIT_MOVE	STATIC	WALKING
SIT_MOVE	0	14	3
STATIC	0	663	0
WALKING	3	76	23
Recall	0	1	0.26
Precition	0	0.88	0.89
F1	0	0.99	0.36

After feature selection Features: standard deviation of x, y, z			
	SIT_MOVE	STATIC	WALKING
SIT_MOVE	0	11	6
STATIC	0	662	0
WALKING	0	59	43
Recall	0	1	0.42
Precition	0	0.88	0.86
F1	0	0.99	0.56

Evaluation SVM

Other type of data

Window				
	CLOSE	CLOSED	OPEN	OPENED
CLOSE	3	4	0	1
CLOSED	0	653	0	0
OPEN	2	0	9	1
OPENED	0	0	0	209
Recall	0.375	1	0.75	1
Precition	0.6	0.994	1	0.991
F1	0.462	0.997	0.857	0.995

Sonar				
	CLOSED	OPEN	PASS	SEMI
CLOSED	707	0	0	0
OPEN	0	90	0	0
PASS	0	0	30	15
SEMI	0	0	17	23
Recall	1	1	0.667	0.575
Precition	1	1	0.638	0.605
F1	1	1	0.652	0.590

Evaluation SVM

Other type of data

DOOR			
	CLOSE	NONE	OPEN
CLOSE	5	3	0
NONE	0	869	0
OPEN	0	0	5
Recall	0.625	1	1
Precition	1	0.997	1
F1	0.770	0.998	1

PRESSURE		
	CLOSE	NONE
SITTING	127	0
STAND	0	756
Recall	1	1
Precition	1	1
F1	1	1

Evaluation SVM

Problem and Reflection

1. Human error in labeling the data
2. The distribution of activities in training data and testing data is not balanced
3. Training samples are not representative

Evaluation
Decision Tree

Graphic structure of Decision Tree output

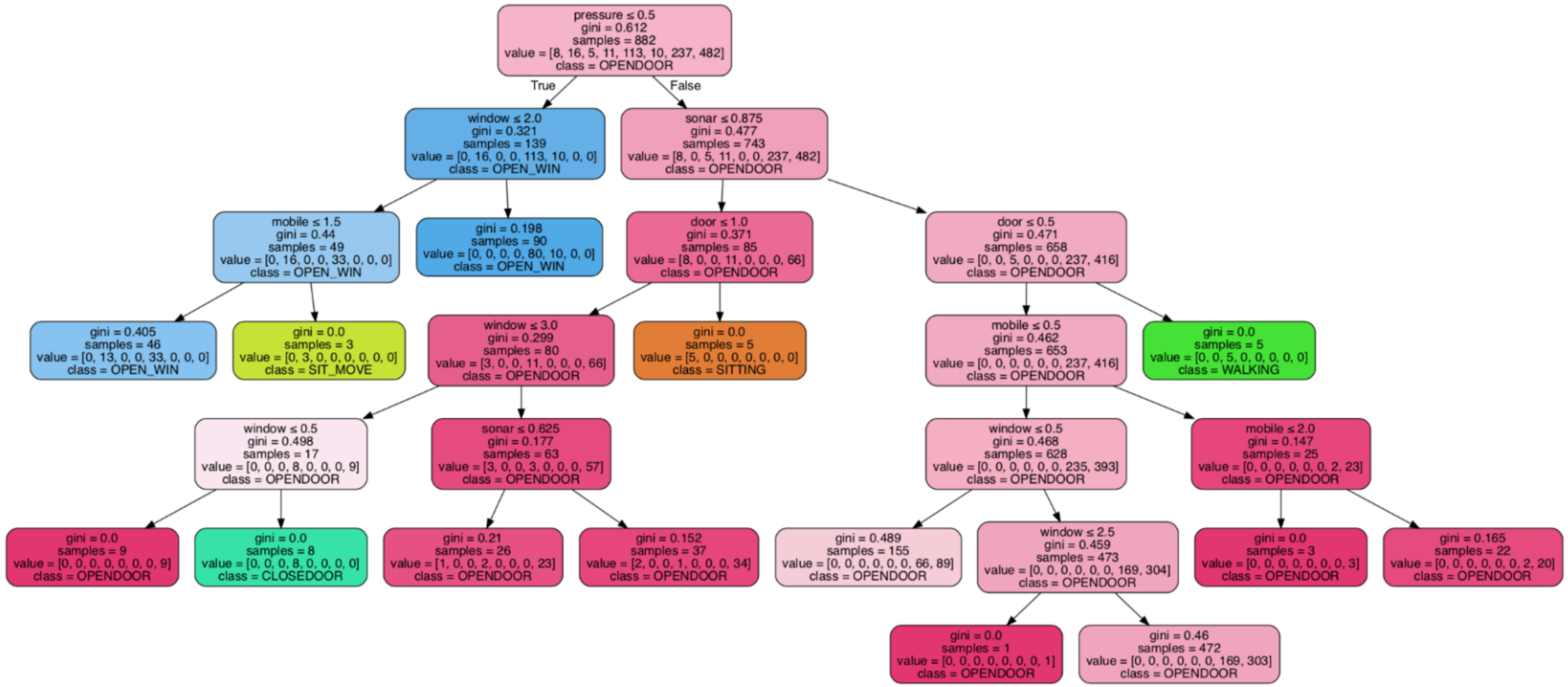
FEATURES		
LUX	TEMP_INSIDE	TEMP_WINDOW
SONAR	MOVEMENT	PRESSURE
ACC_DOOR	ACC_WINDOW	ACC_MOBILE

ACTIVITIES			
OPEN_DOOR	HAND_MOBILE	WALKING	SITTING
CLOSE_DOOR	OPEN_WINDOW	SIT_MOVE	STAND

Evaluation Decision Tree

OUTPUT

value = ['SITTING', 'SIT_MOVE', 'WALKING', 'CLOSEDOOR', 'OPEN_WIN', 'STAND', 'HAND_MOBILE','OPENDOOR']



Conclusion

- Training data determines the classification capability of models
- Feature selection takes effect in improving the performance of models
- Machine learning is feasible for human activities recognition

Future development

- Improve data quality
  - Integrity of data during the transmission
  - Noise remove
- Different feature selection methods
- Other reliable sensors

Questions?