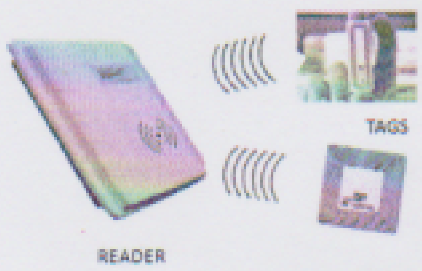
Course "Intelligent Systems"

PROJECT – PART I

A.Y. 2016/2017



An **RFID (Radio-Frequency IDentification) gate** is a physical gate with a fixed RFID reader used for automatic identification of objects or people equipped with RFID tags. The RSSI (Received Signal Strength Indicator) signal represents the strength of the signal emitted by the RFID tag and received by the RFID reader. The higher the strength of the signal, the smaller the distance between the tag and the reader.

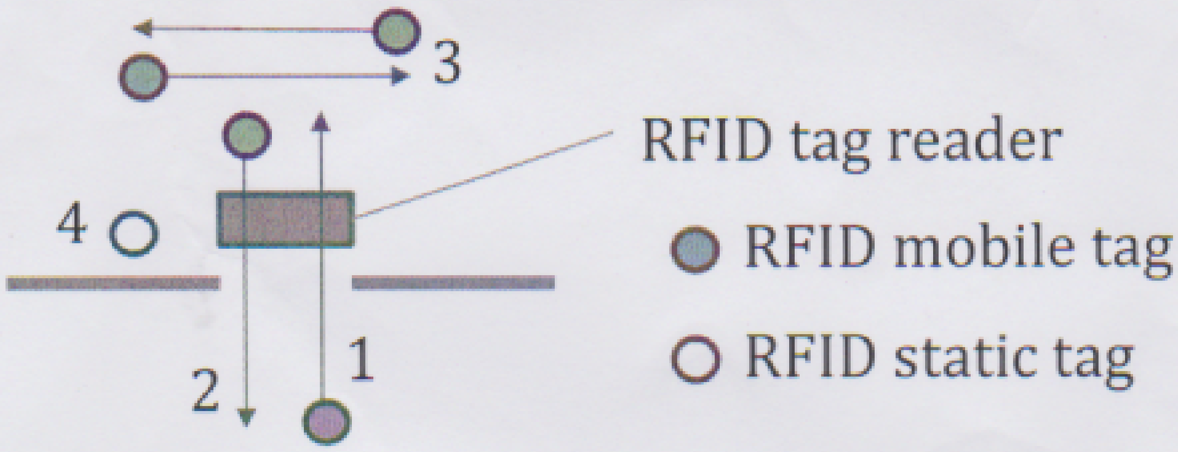
Context: The aim is to study the signals received from RFID tags, placed inside the badge of people in order to control the access to a restricted area (e.g., a room). In particular, the aim is to distinguish between 4 different actions: three dynamic actions and one static action.

- Dynamic actions: 1) *enter* the restricted area, 2) *exit* from the restricted area, 3) *walk in parallel to the gate* inside the restricted area without going out.
- Static action: 4) *stand still* close to the restricted area.

The actions are performed by people equipped with an RFID tag horizontally or vertically oriented with respect to the RFID reader.

Experimental setup

The experimental scenario used to collect data is represented in the following figure:



The experimental scenario includes two RFID tags and one RFID reader. One tag is fixed close to the restricted area, and is used to collect the signals corresponding to static action 4. We refer to this tag as *static* RFID tag. The other tag is used in turn by people to perform the three dynamic actions. Only one action at a time is performed. We refer to this tag as *mobile* RFID tag. The RFID reader is placed over the door of the restricted area (slightly inside the room), because the aim is to detect the accesses to the area. When the RFID reader is turned on, it receives the signals from both the RFID tags present in its operating area: the fixed static tag and the mobile tag.

We performed 4 different experiments using a volunteer. In each experiment the moving person performs one of the three possible dynamic actions. Simultaneously, a static tag is placed near the doorstep to simulate a person standing still (for the sake of simplicity we fixed the static tag on the wall). In addition, in each experiment, the tag orientation was also taken into account. The orientation of the mobile tag can be horizontal (horizontal scenario) or vertical (vertical scenario). The orientation of the static tag is horizontal in all the experiments.

Each experiment (corresponding to a dynamic action and a tag orientation) was repeated 10 times, and the signals from the static and mobile tags were simultaneously collected.

Data description

The dataset consists of:

- 30 different samples corresponding to dynamic actions, belonging to the three possible classes (*enter, exit, walk in parallel*), in the horizontal scenario;
- 30 different samples corresponding to dynamic actions, belonging to the three possible classes (*enter, exit, walk in parallel*), in the vertical scenario;
- 60 different samples corresponding to the static action (*stand still*).

There are 60 .mat files. Each .mat file refers to an action performed with a given orientation of the tag, and contains the signal information related to i) the dynamic action collected with the mobile tag, and ii) the static action collected with the static tag:

- 10 actions of type *enter* with the tag horizontally oriented (files *Dati_TagH_IN_1* - *Dati_TagH_IN_10*);
- 10 actions of type *enter* with the tag vertically oriented (files *Dati_TagV_IN_1* - *Dati_TagV_IN_10*);
- 10 actions of type *exit* with the tag horizontally oriented (files *Dati_TagH_OUT_1* - *Dati_TagH_OUT_10*)
- 10 actions of type *exit* with the tag vertically oriented (files *Dati_TagV_OUT_1* - *Dati_TagV_OUT_10*);
- 10 actions of type *walk in parallel* with the tag horizontally oriented (5 actions from left to right, and 5 actions from right to left) (files *Dati_TagH_Pass_DS_1* - *Dati_TagH_Pass_DS_5*, and files *Dati_TagH_Pass_SD_1* - *Dati_TagH_Pass_SD_5*);
- 10 actions of type *walk in parallel* with the tag vertically oriented (5 actions from left to right, and 5 actions from right to left) (files *Dati_TagV_Pass_DS_1* - *Dati_TagV_Pass_DS_5*, and files *Dati_TagV_Pass_SD_1* - *Dati_TagV_Pass_SD_5*).

Inside each .mat file the only relevant information is the following structure:

-*Inventario*.

Inside each *Inventario* structure there are two relevant data structures:

- *Tag98BD* refers to the mobile tag (attached to the moving person performing the corresponding action);
- *Tag98B6* refers to the static tag (attached to the person standing still).

Tag98BD and *Tag98B6* have the same internal content:

- *RSSITag* vector corresponding to the amplitude values (in dBm) of the RSSI signal received;
- *RNSITag* vector corresponding to the noise values (in dBm) of the RSSI signal received;
- *FaseTag* vector corresponding to the values of the phase of the signal (in degrees);
- *TempoTag* corresponding to the sampling times of the signal (in ms).

The noise values are only used to check if the RSSI signal was collected correctly (i.e., with an acceptable level of noise).

Please, note that other data, with the previous format, will be provided soon.

Project development – Part I

1) *Pattern recognition with neural networks*

The aim is to build hierarchical classifiers organized on two levels.

The first level is made by a 2-class classifier and aims to distinguish between dynamic actions (actions 1, 2, and 3 considered together) and static actions (action 4). The classifier takes as input a representation of each signal and produces as output the corresponding class label (*static* (i.e., *stand still*) or *dynamic*).

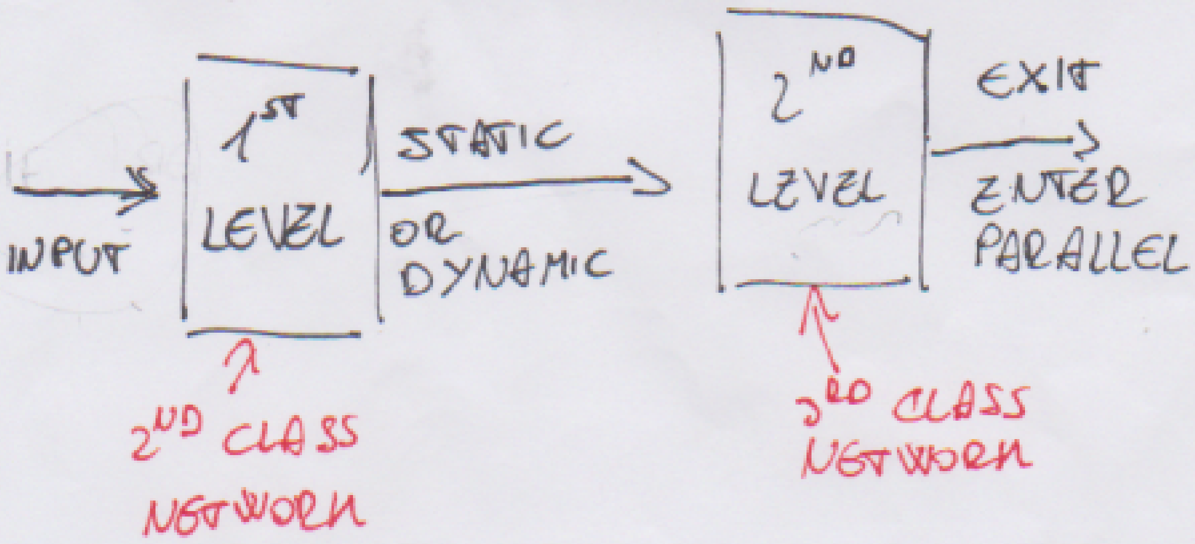
The second level is made by a 3-class classifier and aims to distinguish among the 3 dynamic actions. The classifier takes as input a representation of each signal, which has been classified as dynamic in the first level, and produces as output the corresponding class label (*enter, exit, walk in parallel*).

As the orientation of the RFID tag may influence the shape of the signal, the horizontal scenario and the vertical scenario are considered separately. This means that two hierarchical classifiers should be built, one for the horizontal scenario and one for the vertical scenario.

The signal used as input to each classifier should be appropriately represented, e.g., by applying feature selection, or by extracting summarizing values from each signal (feature extraction).
Use the *Neural Pattern Recognition app* of the *Neural Network toolbox.*

At the end of this step, on the basis of the results achieved, evaluate if the horizontal and vertical scenarios are actually different (i.e., they need to be considered separately) or if they can be considered together (i.e., the orientation of the tag is irrelevant).

The second part of the project will be provided soon.



Course "Intelligent Systems"

PROJECT – PART II

A.Y. 2016/2017

Project development – Part II

2) *Mamdani fuzzy classifier*

Buil two fuzzy hierarchical classifiers (one for the horizontal scenario and one for the vertical scenario), organized on two levels as explained before.
Use the *Fuzzy Logic Designer app* of the *Fuzzy Logic toolbox.*

3) *Adaptive Neuro-Fuzzy Inference System (ANFIS) classifier*

Build two fuzzy hierarchical classifiers (one for the horizontal scenario and one for the vertical scenario), organized on two levels as explained before.
Use the *Neuro-Fuzzy Designer app* of the *Fuzzy Logic toolbox.*

4) *Clustering with self-organizing maps (SOM)*

For each scenario (horizontal and vertical), build two clustering models: i) the first is able to distinguish between *static* and *dynamic* actions, and ii) the second is able to distinguish among the three dynamic activities *(enter, exit, walk in parallel).*
Use the *neural clustering app* of the *Neural Network toolbox.*