Blank Lesson Template

Yellow highlight = required component

Subject Area(s) **Computer Science**

Associated Unit **None**

Lesson Title **Introduction to Recognition Systems**

Header

Image 1 **Image file:** ___? **ADA Description:** ___? **Source/Rights:** Copyright © ___? **Caption:** ___?

Grade Level 12 (10-12)

Lesson # 1 of 1

Lesson Dependency

Time Required 45 minutes

Summary

Students are introduced to the concepts behind recognition systems. They learn about object classification and recognition problems. They learn about the steps involved in the design process of recognition systems.

Engineering Connection

Not long ago, the National Academy of Engineering has set "reverse-engineering the brain" as one of the 21st century grand challenges (http://www.engineeringchallenges.org/cms/challenges.aspx). One of the main characteristics of the human brain is its ability to recognize objects, sounds, words…etc. thus, parts of the human brain can be categorized as recognition systems. Hence, it has become common for engineers to design automated recognition systems that aim to emulate or even surpass the human brain. Some of the most successful and renowned recognition systems include the AFIS (Automated Fingerprint Identification System) and voice recognition systems such as SIRI.

Engineering Category =

1. Engineering design process

Keywords

Recognition Systems, Classification Algorithms, Decision Trees, Training, Testing.

Educational Standards

National and State

Choose standards from http://asn.jesandco.org/resources/ASNJurisdiction or browse educational standards on TeachEngineering.

State/national science/math/technology (provide source, year, number[s] and text):

ITEEA Educational Standard(s)

ITEEA (provide standard number, grade band, benchmark letter and text):

Pre-Requisite Knowledge

Learning Objectives

After this lesson, students should be able to:

- Explain how recognition systems are designed.
- Identify the key to a successful recognition system design.

Introduction / Motivation

Use your iPhone or your Android voice recognition system to text your friend "I am just teaching a class, don't reply". Ask the students:

- How do you think the cell phone recognized what I was telling it?
- Do you think the voice recognition system in your phone is smart?
- Can it make errors?
- What if you have two contacts in your phone, one is "Sara" and the other one is "Sarah"?
- Suppose you are in the car in the highway (not driving of course) and the window is open while you are trying to use your voice recognition system, do you think it will understand everything you are trying to say?
- Write down a list of possible limitations of your voice recognition system.

Lesson Background & Concepts for Teachers

Recognition Systems:

Recognition systems are computer applications based on algorithms which can automatically recognize or categorize objects of interest. An algorithm is a sequence of well-defined instructions. Algorithms that take *measurements* as an input and give *class labels* as output are usually called *classification algorithms*. For example, an algorithm can take *measurements* such as *height*, *skin color*, and *hair color* of person and outputs the *country of origin* of that person. The *country of origin* in this case is called a *class label*. Mathematically, a recognition system or a classification algorithms can be seen as function mapping $y=f(x)$ where y is the output label and x is (are) the input measurement(s).

Recognition System Design:

The design process of a recognition system undergoes two main steps: *training (learning)* and *testing*. The *training* step also called the *learning* step basically consists of learning the function ***f(.)*** from a set of training examples. For instance, say we want to design a recognition system that can identify whether a person is Asian or North American from his/her height. We would first measure the height from a sample of the Asian population and a sample of the North American population. Then we can learn that a specific height threshold *t* distinguishes between the two populations. Therefore, the learned function ***f(.)*** can be written as follows:

$$f(\boldsymbol{x}) = \begin{cases} 1 & if\ \boldsymbol{x} > t \\ 2 & if\ \boldsymbol{x} < t \end{cases}$$

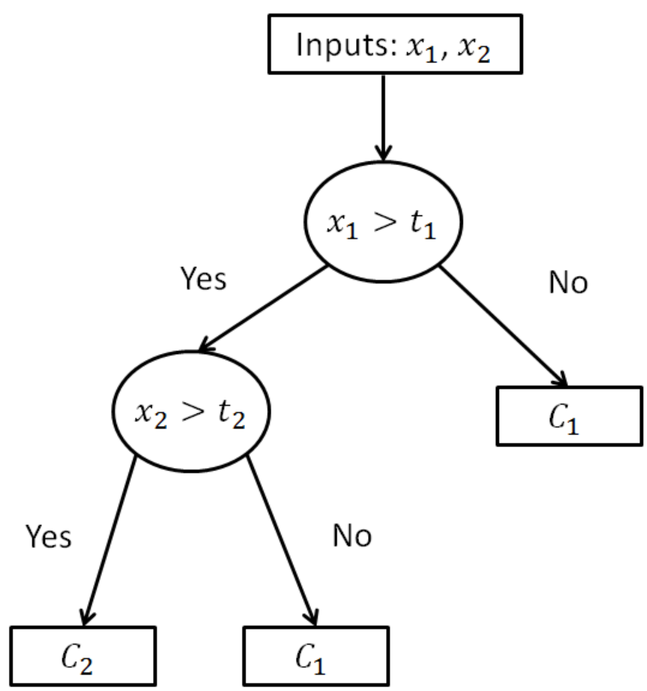
Where the number 1 represents the North American population and 2 represents the Asian population.

However, since neither all North American people have height larger than ***t*** nor all Asian people have height smaller than ***t***, the recognition system will make errors. In order to assess the accuracy of the system, another sample set of heights is collected from both populations. The sample set is called *testing data*. The testing data is run through the recognition system and the number of correctly and falsely classified samples is recorded, hence, allowing a measure of accuracy of the system. This last step is called the *testing* phase of the design.

Decision (classification) Trees:

In the previous section, we considered an example of a classification problem with a single measurement, what if there was more than just one measurement i.e. multivariate data. In this case, more sophisticated functions (algorithms) ***f(.)*** are considered.

Decision trees seek to find a function ***f(.)*** that predicts the class label of an object based on a single or several measurements. A decision tree diagram is depicted in Figure 2.



The decision tree is composed of a root, terminal leafs (in squares) and internal decision nodes (in circles) as shown in Figure 1. Each decision node applies a decision ***f(x)*** for a given input ***x***. At each node, a decision is made and one of the branches is taken depending on the outcome. The outcome of the classification is the value written in the leaf.

Image Insert Image # or Figure # here [use Figure # if referenced in text]

Figure 1

Image file: ___?

ADA Description: ___?

Source/Rights: Copyright © ___?

Caption: Figure 1. ___?

Vocabulary / Definitions

Word	Definition

Associated Activities

Missile Detection System

Lesson Closure

Assessment

Written Answers: Collect students' written answers to the last question of the introduction. (See below a suggested answer).

Limitations of Recognition System:

- Not adaptive: sometimes recognition systems are not adaptive, one could take the example of language accent issues with voice recognition systems.
- Not robust to noise: if there is noise surrounding the system, for example highway noise in the case voice recognition systems.
- Not intelligent: this is the main limitation of recognition systems. Say, you can speak French but with some grammatical mistakes. A French person would be able to infer what you are saying even if you switch verbs with adjectives whereas a recognition system would not be able to do that.

Additional Multimedia Support

References

Attachments

Other

Redirect URL

Contributors

Roberto Dimaliwat, Amin Merouane

Supporting Program

Acknowledgements

Blank Activity Template

Yellow highlight = required component

Subject Area(s) **Computer Science**

Associated Unit **None**

Associated Lesson **Introduction to Recognition Systems**

Activity Title **Missile Detection System**

Header

Image 1 **Image file:** ___? **ADA Description:** ___? **Source/Rights:** Copyright © ___? **Caption:** ___?

Grade Level 12 (10-12)

Activity Dependency

Time Required 45 minutes

Group Size

Expendable Cost per Group US $___

Summary
Students learn how real world recognition systems are designed. They will apply the concepts of decision trees for designing a missile/airplane detection system on simulated data.

Engineering Connection
Missile or airplane detection systems are complex systems that require a significant amount of engineering design. In general, the systems are designed so that to have two main parts: a sensor (radar usually), and a recognition system. The sensors detect and collect measurements from targets of interest (any flying object) such as speed, size, direction …etc. Then the recognition system identifies whether the object is an airplane or a missile.

Engineering Category =
1. Engineering design process

Keywords
Recognition Systems, Classification Algorithms, Decision Trees, Training, Testing.

Educational Standards
National and State
Choose standards from http://asn.jesandco.org/resources/ASNJurisdiction or browse educational standards on TeachEngineering.
State/national science/math/technology (provide source, year, number[s] and text):

ITEEA Educational Standard(s)
ITEEA (provide standard number, grade band, benchmark letter and text):

Pre-Requisite Knowledge

Microsoft Excel.

Learning Objectives

After this activity, students should be able to:

- Explain how recognition systems work.
- Relate simple recognition system concepts to real-life applications.

Materials List

Each group needs:

- A computer with Microsoft Excel.

To share with the entire class:

-

Introduction / Motivation

Although we might not be aware of it, recognition systems constitute a main part of the modern technologies being used by our society. Financial institutions such as banks use recognition systems for fraud detection, law enforcement agencies use facial and fingerprint recognition systems. In military applications, recognition systems can be used for threat detection. In this activity, you will play the role of an engineer whose company has a contract with the US army. Your task will be to design and assess the performance of a system that can distinguish missiles from airplanes. You will be given a dataset with object measurements, namely speed and size of missiles and airplanes. You will have to split your data into a training set and a testing set, design your system and calculate your recognition performance.

Vocabulary / Definitions

Word	Definition

Procedure

Background

Before the Activity

- Review the concepts and the terminology used in recognition systems such as training set, testing set and decision trees from the associated lesson.

With the Students

1. Open the dataset excel sheet (attached), split your datasets into two parts, half for training and half for testing.
2. Provide a scatter plot of object size versus object speed. Plot the missile and airplane data on the same graph. The plot should look like Figure 1 below.
3. From your plots, you can notice that airplanes have larger size and smaller speed in most cases than missiles, now you need to design your recognition system. For this case, you will have to use a decision tree as depicted in Figure 2. The parameters of your system are the thresholds ***t1*** and ***t2***. You will have to choose them.
4. Calculate the performance of your system using the test data. One way to calculate the performance is to count the number of falsely detected objects and divide that number by the total number of objects in the testing set.
5. Redo the experiment for five different values of ***t1*** and ***t2***.
6. Write a brief paragraph describing based on what criteria you would design your system i.e. select your thresholds? Explain.

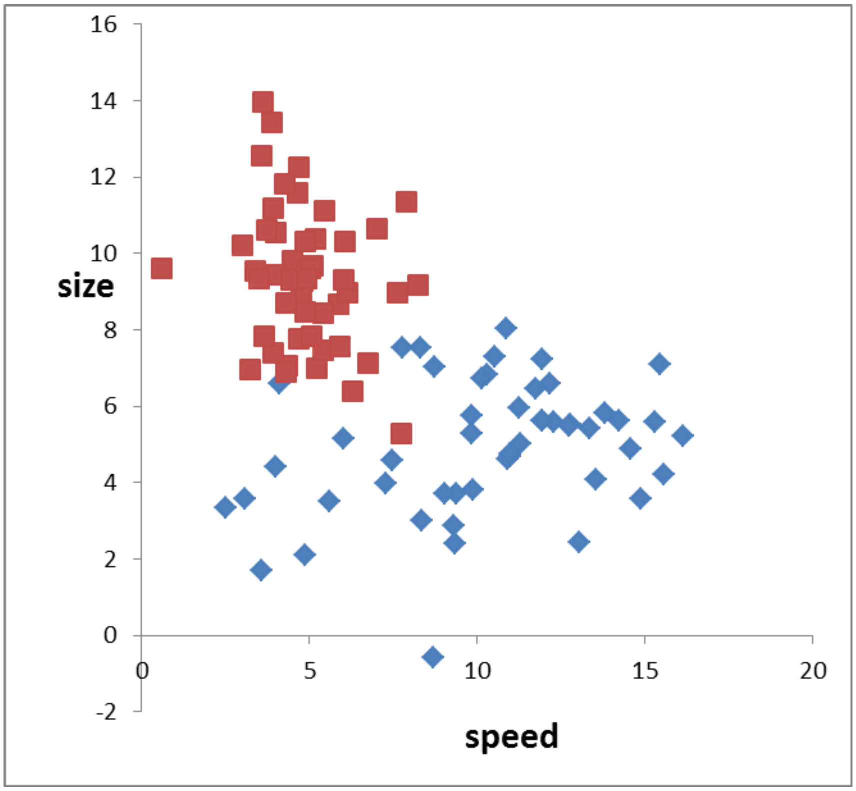


Figure 1: Scatter plot of size versus speed. Squares in red represent airplanes. Diamonds in blue represent missiles.

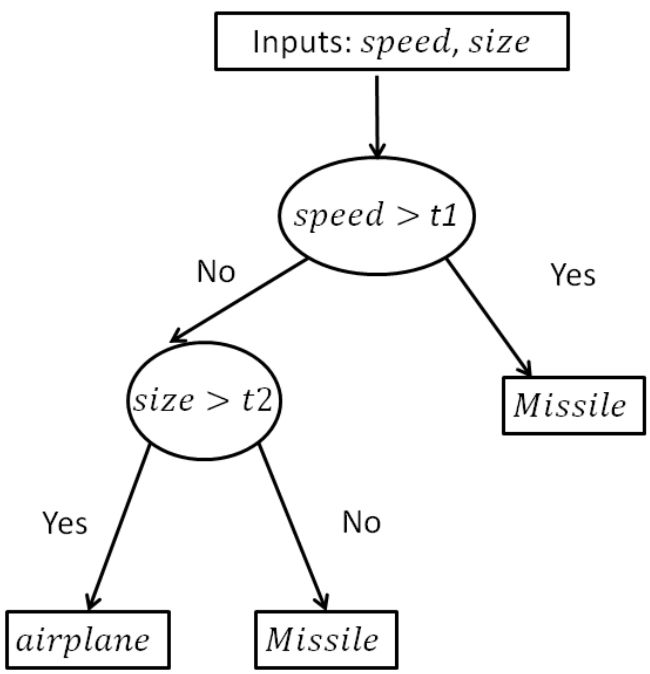


Figure2: Decision Tree System for Missile/Airplane Detection

Attachments

Airplane_Missile_Data_and_Calculations.xlsx

Safety Issues

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Troubleshooting Tips

Investigating Questions

Assessment

Pre-Activity Assessment
Descriptive Title: None

Activity Embedded Assessment
Descriptive Title: None

Post-Activity Assessment
Descriptive Title: Collect students' written answers to the last question of the introduction. (See below a suggested answer).
Typically, one can choose thresholds ***t1*** and ***t2*** based on the performance of the recognition system. This is the most logical answer in most cases. Nonetheless, for different applications this answer changes because other factors have to be considered. In our case, for missile detection systems, it would make more sense to over-detect the missiles i.e. making sure that a missile is always correctly detected. However, this will increase the number of false alarms (planes detected as missiles) and reduce the overall performance of the system.

Activity Extensions

Activity Scaling

- For lower grades, ___?
- For upper grades, ___?

Additional Multimedia Support

References

Other

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Contributors

Roberto Dimaliwat, Amin Merouane

Supporting Program

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Classroom Testing Information