Acknowledgement

All notes in this chapter are based on an online article by Sing Li (http://www.ibm.com/developerworks/java/library/j-robocode/index.html).

This chapter will not cover any topics associated with neural net learning. Its purpose is to acquaint the reader with the tools necessary to complete the coursework: Robocode, the java programming language and the Eclipse IDE.
Robocode is an easy-to-use robotics battle simulator that runs on all platforms that support Java 2. Robocode is the brainchild of Mathew Nelson, a software engineer in the Advanced Technology, Internet division at IBM.

You create a robot, put it onto a battlefield and let it battle to the bitter end against opponent robots created by other developers. Each Robocode participant creates his or her own robot using elements of the Java language, enabling a range of developers, from rank beginners to advanced hackers to participate in the fun.
The coursework requires each student to develop and submit their own Robocode robot. And because this course is about architectures for learning systems, it is required that you apply (and be able to demonstrate) what you learn in class, to your robot. As a minimum, you must use the error backpropagation algorithm as applied to multi-layer perceptrons and reinforcement learning in aspects of your robot’s attack or defence strategy. Instructions will be provided as to where and how to apply these learning methodologies.
The latest version of Robocode can be found at http://robocode.sourceforge.net/

The latest version of Robocode is v1.9.2.6 as of 20 September 2017. Note that this version requires JDK 1.6 on your machine.

Installation is straightforward. Just run robocode-setup.jar within your java VM.
After your installation, you can start the Robocode system from either the shell script (robocode.sh) or batch file (robocode.bat). There is also an icon. Robocode is supported for all platforms, including Windows, Mac and Linux.
The battlefield is the arena where battle between the robots takes place. It houses the main simulation engine and allows you to create, save and open new or existing battles. You can pause and resume the battle, terminate the battle, destroy any individual robot, or get the statistics of any robot using the controls available in the arena. Furthermore, you can activate the Robot Editor from this screen. The Robot Editor is a customized text editor for editing the Java source files that make up a robot. It integrates both the Java compiler (for compiling robot code) and the customized Robot packager in its menu. Any robot created with the Robot Editor and successfully compiled is in a ready-to-deploy location for the battlefield. A robot in Robocode consists of one or more Java classes. These classes can be archived into a JAR package. Robocode provides a "Robot Packager" that can be activated from the battlefield GUI window, for just this purpose.

Tip: Watching a battle unfold can be lengthy at times. If you would like to speed things along and are happy not to actually watch the battle, minimize the Robocode window. The battle continues but since the java Virtual Machine (VM) no longer needs to generate a graphical output, you’ll find it progresses much much faster! When it comes to reducing learning times, you’ll find this very useful.
Note that the robot has a rotating gun, and on top of the gun is a rotating radar. The robot vehicle, the gun, and the radar can all rotate independently. At any moment in time, the robot's vehicle, the gun, and radar can be turned in different directions. By default, these items are aligned, facing the direction of the vehicle movement.

You can also fix the direction of the gun turret and the radar for that matter, to always point in the direction the tank is heading. Might be useful if you’re in pursuit!

The radar is able to detect any tank within a certain distance.
Note that with the default battlefield size of 800 x 600 pixels, the maximum distance between you and any other tank is 1000 pixels. This is within your scanning range of 1200 pixels. I.e. you can scan any tank in a battlefield of this size.

Some other useful information:

• Your gun heats up and rapid fire attempts will be unsuccessful. You should query the heat of the gun before firing if you need to be sure of a successful shot.

• The radar is unable to detect enemy bullets.

• See the wiki at [http://robowiki.net/wiki/Robocode](http://robowiki.net/wiki/Robocode) for more details.
The most useful piece of information you’ll likely apply is the relative bearing of a scanned opponent. In Robocode, upon scanning an enemy, if the very next command you issue is fire, your tank will turn this amount first before firing. I.e. it will automatically point at the scanned tank, then fire. Handy!
A strategy where your tank tries to stay out of trouble and does not attack, may be enough to survive until the end of a round. However, since points are awarded for killing enemy tanks, you should be aware that such a strategy may not be satisfactory to win overall.

After a battle, Robocode collects the scores and generates a rankings table showing who is 1st, 2nd etc.

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**Scoring**

- Points are scored for certain events
  - E.g. hitting enemy tank, killing enemy tank
- Damage is incurred for certain events
  - E.g. hitting or ramming enemy tank
    - Hit \( +(3 \times \text{fire power}) \)
    - Miss \( -\text{fire power} \)
    - Ram \( +1.2 \)
    - Being rammed \( 0.6? \)
- You can win on points even if you get killed!
- See [http://robowiki.net/wiki/Robocode/Game_Physics](http://robowiki.net/wiki/Robocode/Game_Physics) and [http://robowiki.net/wiki/Robocode/FAQ](http://robowiki.net/wiki/Robocode/FAQ)
Entering robots into a battle is easy. From the Robocode Battle menu, select New. From here you should be able to see your robot and others in the dialog that pops up.

**Starting a Battle**

- Start Robocode
- Select the *Battle* menu
- Find your robot and others that you would like to enter into battle!
- If you out survive all others, you win a *round*!

**Tip:** Minimizing the window makes the simulation run faster!
Creating your own Robots

```java
package sarb;
import robocode.;;

/**
 * MyFirstRobot - a robot by (sarb)
 */
public class MyFirstRobot extends Robot
{
    ... // <<Area 1>>
/**
 * run: MyFirstRobot's default behavior
 */
    public void run() {
        ... // <<Area 2>>
        while(true) {
            ... // <<Area 3>>
        }
    }
    ... // <<Area 4>>
    public void onScannedRobot(ScannedRobotEvent e) {
        fire(1);
    }
}
```

The following shows you what you get to start with when you create your first robot. <<Area 1>> is typically used to declare global variables. They will be accessible from anywhere in your code. <<Area 2>> is inside the robot’s “run” method which is called from within Robocode to instruct your robot to start. <<Area 2>> will typically contain code that only needs to be executed once per robot instance. E.g. to get the robot into some predetermined state. <<Area 3>> is the endless while loop that controls the normal behaviour of your robot. I.e. what your tank is doing when it is not firing or acting on a radar event. <<Area 4>> is where you implement helper methods and event handlers that determine how your robot will react to certain events. The robocode editor generates two of these event handlers, onScannedRobot and onHitByBullet, automatically for you.
public class MyFirstRobot extends Robot
{
    public void run() {
        while(true) {
            // Replace the next 4 lines with any behavior you would like
            ahead(100);
            turnGunRight(360);
            back(100);
            turnGunRight(360);
        }
    }

    /**
     * onScannedRobot: What to do when you see another robot
     */
    public void onScannedRobot(ScannedRobotEvent e) {
        fire(1);
    }

    /**
     * onHitByBullet: What to do when you're hit by a bullet
     */
    public void onHitByBullet(HitByBulletEvent e) {
        turnLeft(90 - e.get-bearing());
    }
}
The slide shows a screen show of the very simple editor that comes with Robocode.
One useful feature of this “IDE” is that it allows you to package up your robots into a java archive (jar) file. This is what you would typically upload to the many online robot repositories.

However, the editor is quite basic. Instead, Eclipse is recommended.
Class Robot methods

- Robocode installation comes complete with Java docs.

- Look for javadoc\index.html

- There are lots of methods e.g.
  - void ahead (double distance)
  - void fire (double power)
  - double getEnergy ()
  - void turnLeft (double degrees)
  - void turnRadarLeft (double degrees)

void ahead() moves your robot forward the specified distance. Units of distance are pixels.
void fire() fires a shot with the specified power.
double getEnergy() will return how much energy you have left.
void turnLeft() rotates your robot the specified number of degrees anticlockwise.
void turnRadarLeft() turns your robots radar the specified number of degrees to the left.

These are just a few of the methods supported by the Robot class. See the javadocs for the rest. Note that these methods are all synchronous methods. That is they will block execution until each method completes. So if your code looks like:

    ahead(100);
    turnGunRight(30);
    fire(1);

Your 'bot will first travel 100 pixels. Upon getting there the gun will turn right 30 degrees. Upon completion of that your robot will fire. If you derive your robot from class AdvancedRobot, it provides all these methods plus some asynchronous methods. More on this later.
When something happens in Robocode, e.g. you get hit, Robocode needs to know how you would like to react to, or handle this event. In software engineering, callback methods are a common way of implementing such event handlers and in languages such as C++ and Java, callbacks typically manifest themselves as virtual methods. The following is a sampling of some of the virtual methods that Robocode will call and expects you to implement:

- **void onBulletHit (BulletHitEvent event)**: called when a bullet your robot fires, reaches a target. The event parameter passed to you by this method can provide you with some valuable information. For example, the `BulletHitEvent` class allows you to obtain the attacked robots name and energy.

- **void onHitByBullet (HitByBulletEvent event)**: called when your ‘bot is hit. The event parameter passed to you tells you the name of the robot that fired the bullet, the bearing to the bullet, the power of the bullet etc.

- **void onScannedRobot (ScannedRobotEvent event)**: called when your robot scans another. As you may expect this event can tell you all sorts of information about who you’ve just spotted!

These are just a small sample of the events supported by Robocode. There is even an `onWin()` event called when you win a round as well as an `onDeath()` handler. Robocode provides an implementation of this last one...
for you so you don’t have to explicitly implement this method. Unless you need to perform some cleanup (e.g. closing a file) on robot death.
Deriving from the AdvancedRobot class provides further methods. Notably asynchronous robot commands. Consider the following example:

```java
setAhead (100);
setTurnLeft (30);
setFire(1);
execute();
```

In this case, each method completes immediately and your robot does nothing until you return control back to Robocode. You do this by issuing the execute method. When execute is reached, Robocode will start all requests at the same time and advance your tank as much as possible in one tick of the clock. This tick represents a single frame of motion. To find out how much your tank actually travels in one tick you need to look at the physics of the tank. E.g. maximum tank speed is 20 pixels per tick and turn rate is 20 degrees per tick. These commands will remain in an event queue that Robocode creates for you. The event queue is checked each tick. Once the commands are complete, the events are removed from the queue. Note that there is a waitFor() method that you may use to wait for a particular condition to complete. E.g. you may want to wait for your tank to complete its 30 degree turn before firing. By the way, can you see what path the first two setAhead & setTurnLeft commands above would cause the tank to take?

At times it will be necessary for you to write out information to a file. In this
case you cannot use the java.io, FileStreamOutput methods. Java security prohibits this. Instead, you have to use a Robocode class for this. RobocodeFileStreamOutput.
Eclipse is a popular IDE introduced by the Eclipse Foundation. It is written in Java and admittedly, early versions were sluggish in use. However, the latest versions are slick. Of course it can be used to develop Java, but the IDE is not restricted to any one language. I would highly recommend you use this to develop your robots for this course. It is far more user friendly than the basic editor that comes with Robocode. For those new to Java, it supports class browsing and method completion, so you don’t have to rummage around for Robocode documentation elsewhere. Compilation errors are highlighted as you type and Eclipse in some cases, will suggest fixes. Very useful, if you are a beginner to Java.
As with Robocode, you will need a preinstalled java virtual machine on your PC or Mac. Eclipse is being continually updated and I fully expect there to be newer versions in the future.
When creating a project, Eclipse will look for folders containing java source files. These folders will appear as “packages” in the browser. It’s important to make sure that the location selected for the external location is a directory above where the folder containing the actual robot folders is. Each folder will then appear as a package in Eclipse Package explorer view on the left.

If you don’t see a ‘sample’ and ‘sample team’ package, try selecting a folder even higher, e.g. the robocode folder itself.
How to setup Eclipse for Robocode

- Next you need to add the library for robocode.

- Select the project in the Package Explorer window
  - Select menu item File->Properties
  - Select Java Build Path in Properties dialog
  - Select the Libraries tab
  - Then press Add External Jar
  - And browse to and locate robocode.jar
  - Done

Robocode.jar will be in the directory where robocode is installed.
The Package Explorer view will show you all folders installed by Robocode under ‘robots’. Each folder containing java source code will appear as a package. Opening a package lists all java source files. Double clicking on one of these source files will open the file in the editor window (not shown above). Eclipse makes it easy traversing classes and methods. If you haven’t correctly set up the external location, you will see warning symbols against each package and source file. At least when initially setting up Eclipse using the previous instructions, you should not see any such problems.
How to use Eclipse with Robocode

- Eclipse automatically compiles all java files.
- Eclipse can even be set to automatically build
  – i.e. create ‘.class’ files.
- Once built, you can switch to robocode to try out
  your newly compiled robot!

With the appropriate settings, Eclipse can be set to automatically compile and build java files in the background. This is done when you save the updated java source. By default, the compiled class file is created in the same directory the source file is.

After editing and saving a robot in Eclipse, your compiled robot will be ready to enter into a battle straight away!
IntelliJ

- Sees broader use in industry than Eclipse
- Nicer, in my opinion
- Will appeal to PyCharm users
IntelliJ - Setup

- You need to follow some conventions

- Compiled class files will appear in an out folder. Location can be changed via Open Module Settings menu item.

- Source files should go in a folder called src. Which does not have to be the 'main' folder.

- Java conventions dictate that all libraries including your own code belong to a package. Here is a sample package naming: `com.apache.spark.sql`...

- If you have test files, put them in a folder called test and mark the folder as a test folder.
IntelliJ – Setup 2

- Tell Robocode where your class files are

- the path is just one above the package folder
  - (it won't work if you go deeper)
IntelliJ – Some issues

- Robots that write to a file may violate Java security!

  – Add this to your VM arguments in your run configuration

    - -DONOSEcurity=true

    – Not the best answer, but a workaround until I find a proper solution.
Upon starting a battle, Robocode will call the SpinBots run method, which simply puts the tank in an endless while loop. So if no other event handler is triggered, this tank is programmed to go ahead a distance of 10000, while at the same time turning right. The end result is that SpinBot goes around in circles! Can you guess what would happen if the velocity was increased?

```java
import robocode.*;

/**
 * SpinBot - a sample robot by Mathew Nelson
 *
 * Moves in a circle, firing hard when an enemy is detected
 *
 public class SpinBot extends AdvancedRobot {

 /**
 * SpinBot's run method - Circle
 */
 public void run() {
   while (true) {
     // Tell the game that when we take move,
     // we'll also want to turn right... a lot.
     setTurnRight(10000);

     // Limit our speed to 5
     setMaxVelocity(5);
     // Start moving (and turning)
   }
}
```
Here we see two event handlers. Upon scanning the action is quite simple. SpinBot will fire with a power setting of three. Note that Robocode will automatically turn the robot using the bearing returned in the scanned event prior to firing. This happens only if the first command in this event handler is fire.

The next event handler attempts to deal with the situation if SpinBot hits another robot. Robocode can even tell you if it was your fault for hitting the other robot!
Robocode web resources

- There are lots of resources. Try:
- Excellent two part article by Sing Li
- Robocode Wiki

Sing Li’s article can be found at:
The Robocode wiki page is http://robowiki.net/wiki/Main_Page
How to track bullets:
In fact there are many resources and literature on the web that you will find useful.

All links valid at time of writing (September 2016).
The assignment for this course requires you to develop your own Robocode robot. The course will cover a number of topics related to neural networks, including learning algorithms, data representation and heuristics. Multi-layer perceptrons and reinforcement learning are two of the topics covered. To complete this course, you are expected to demonstrate the use of these two algorithms within the development of your robot. Of course, while building a strong adversary is a nice goal, it is more important to show your understanding of the techniques taught in the course and your ability to apply them in practice. Its also hoped that this will be a fun and challenging coursework assignment.

For more details visit http://www.ece.ubc.ca/~eece592/ and click on the “coursework” link.
Consider applying reinforcement to other robot actions. For example, being rammed by another robot or hitting a wall incurs damage. As of course does being hit by an enemy bullet! However, the scanning of enemy bullets in Robocode is unfortunately not supported. Does this mean enemy bullets cannot be avoided? Perhaps not. Would it instead be possible to predict if an enemy was about to fire at you once scanned? If so, such information would be critical in directing robot motion for bullet avoidance. For example, the energy of a robot will drop by a value between 0.1 and 3 when it fires. While not unique, this figure may be sufficient to tell if an attack is imminent.