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Appendix A

Multi-Agent System

A.1 Introduction

This section provides screenshots of the multi agent system of the meditation solution and the jade configuration.

A.2 Multi agent system – Meditation solution

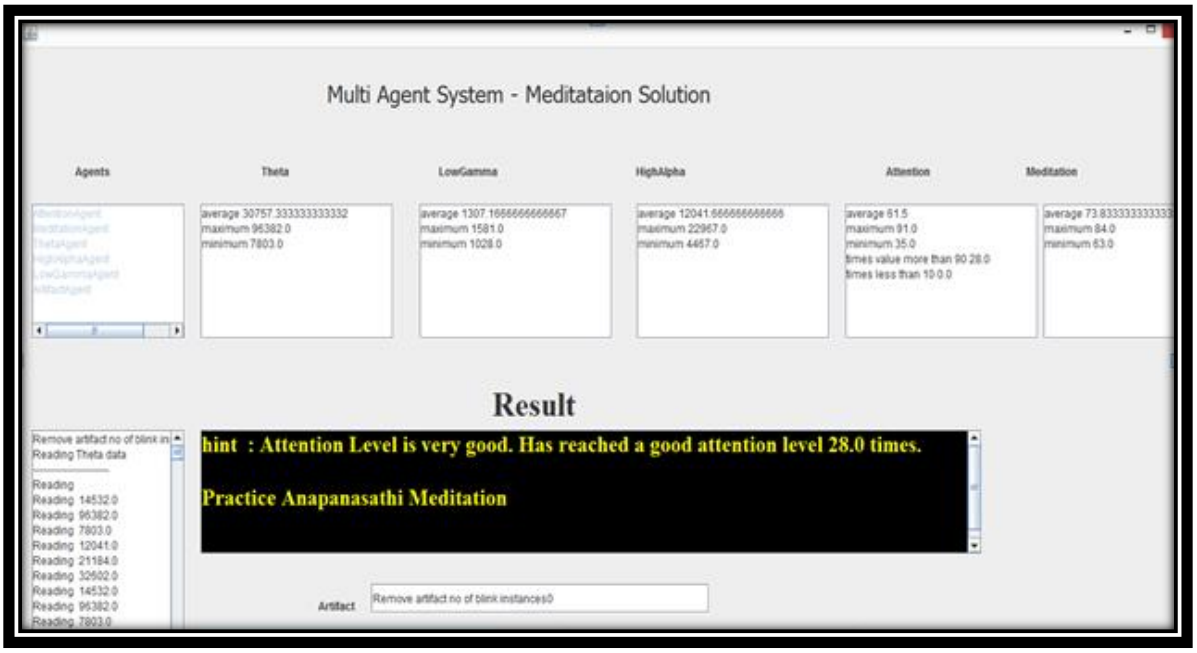
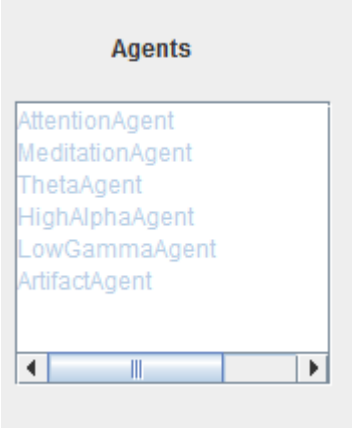
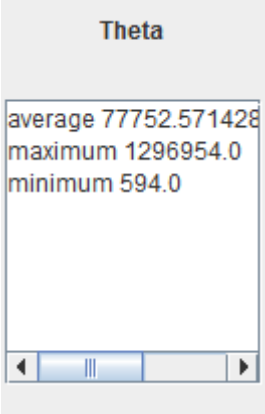


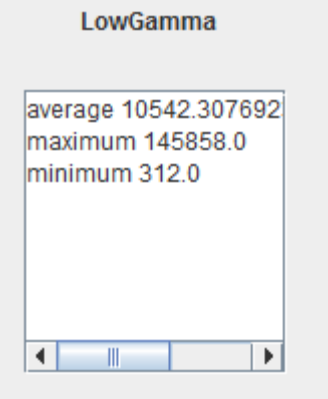
Figure 10.1: Multi agent system results

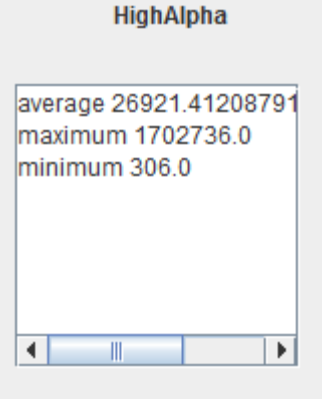
The activated agents are listed

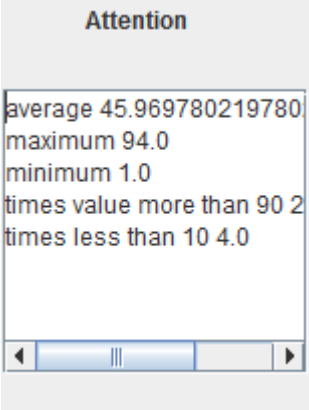


Various agents have data which they get from the environment. (From sensors)



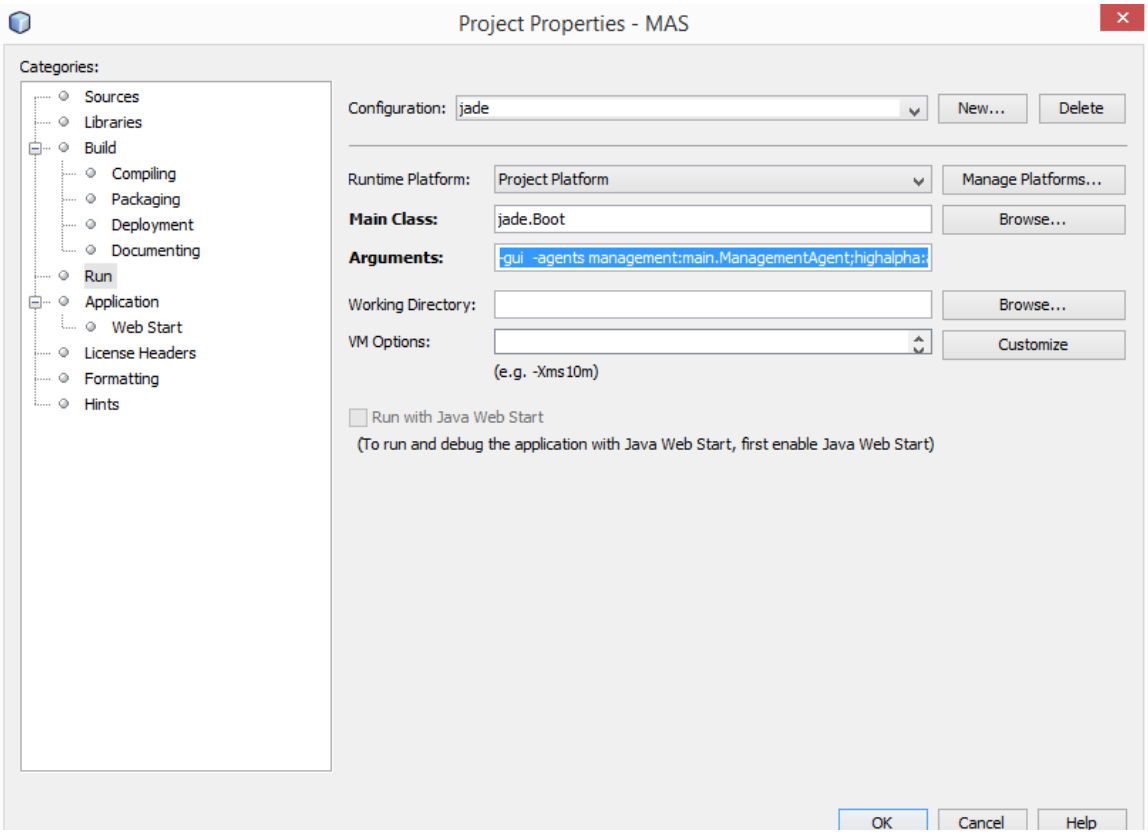






Setting up JADE

JADE (Java Agent Development Framework) is a software Framework fully implemented in the Java language. It simplifies the implementation of multi-agent systems through a middle-ware that complies with the FIPA specifications. JADE is free software and is distributed by Telecom Italia, the copyright holder, in open source under the terms and conditions of the LGPL (Lesser General Public License Version 2) license.



-gui -agents management:main.ManagementAgent;highalpha:agents.HighAlphaAgent;theta:agents.ThetaAgent;decision:main.DecisionAgent;attention:agents.Attentionagent;meditation:agents.Meditationagent;art:agents.ArtifactAgent;lowgamma:agents.LowGammaAgent

Appendix B

Source code of the system

B.1 Introduction

This section will include source code which was used to develop the proposed system.

B.2 Source code of the proposed system

Code snippet from AttentionBehavior

```
private void Report() {
      AID r = new AID("management@" + myAgent.getHap(), AID.ISGUID);

      ACLMessage aclMessage = new ACLMessage(ACLMessage.INFORM);
      aclMessage.addReceiver(r);
      try {
         List<String> esense = TextFileReader.readData("attention");
         String eeg = TextFileReader.readAverage(esense);
         aclMessage.setContent("aaaaa" + eeg + "-" + TextFileReader.readMax(esense) +
"-"+TextFileReader.readMin(esense)+"-" + TextFileReader.getValueList(esense)+
               "-"+                              TextFileReader.moreThan90(esense)+"-"+
TextFileReader.lessThan10(esense));

      } catch (Exception e) {
         e.printStackTrace();
      }

      myAgent.send(aclMessage);
   }
```

Code snippet calculating average

```
public static HashMap<String, Integer> EegPowerAverage(List<JSONObject> obj)
throws JSONException {
```

```
        int deltasum = 0, thetaSum = 0, lowAlphaSum = 0, highAlphaSum = 0, lowBetaSum
= 0;
        int highGammaSum = 0, highBetaSum = 0, lowGammaSum = 0;
        int attentionSum = 0, meditationSum = 0;

        for (JSONObject obj1 : obj) {
            deltasum += (int) obj1.get("delta");
            thetaSum += (int) obj1.get("theta");
            lowAlphaSum += (int) obj1.get("lowAlpha");
            highAlphaSum += (int) obj1.get("highAlpha");
            lowBetaSum += (int) obj1.get("lowBeta");
            highGammaSum += (int) obj1.get("highGamma");
            highBetaSum += (int) obj1.get("highBeta");
            lowGammaSum += (int) obj1.get("lowGamma");
        }

        HashMap<String, Integer> hmap = new HashMap<>();
        hmap.put("deltaAvg", (deltasum / obj.size()));
        hmap.put("thetaAvg", (thetaSum / obj.size()));
        hmap.put("lowAlphaAvg", (lowAlphaSum / obj.size()));
        hmap.put("highAlphaAvg", (highAlphaSum / obj.size()));
        hmap.put("lowBetaAvg", (lowBetaSum / obj.size()));
        hmap.put("highGammaAvg", (highGammaSum / obj.size()));
        hmap.put("HighBetaAvg", (highBetaSum / obj.size()));
        hmap.put("LowGammaAvg", (lowGammaSum / obj.size()));

        return hmap;
    }
```

Retrieving minimum, maximum and average

```
public static String readAverage(List<String> obj) {

    int size = obj.size();
    double count = 0;
    for (int i = 0; i < size; i++) {
        count = count + Double.parseDouble(obj.get(i));
    }

    String avg = Double.toString(count / size);
    return avg;

}

public static String readMax(List<String> obj) {

    double max = 0;

    for (String obj1 : obj) {
        double val = Double.parseDouble(obj1);
        if (val > max) {
            max = val;
        }
    }
```

```
    return Double.toString(max);
}

public static String readMin(List<String> obj) {

    double min = Double.parseDouble(obj.get(0));
    for (String i : obj) {
        double temp = Double.parseDouble(i);
        min = min < temp ? min : temp;
    }

    return Double.toString(min);
}
```

Code from ANN Approach

loadTrianedANN

```
public void loadTrianedANN()
   {
      setTrainedNetwork(new BasicNetwork());
      eegDataTxtArea.append("Loading ANN\n");
      try
      {
         FileInputStream fin = new FileInputStream("meditationsol.dat");


         ObjectInputStream ois = new ObjectInputStream(fin);
         setTrainedNetwork((BasicNetwork) ois.readObject());
         ois.close();


         eegDataTxtArea.append("Loading ANN Completed\n");
      } catch (IOException | ClassNotFoundException e)
      {
         JOptionPane.showMessageDialog(null, e.getMessage());
      }
   }
```

startEEGMonitoring

```
            if (currentEEGReading.contains("eSense"))
            {

eegDataTxtArea.append(currentEEGReading.substring(currentEEGReading.indexOf("ee
gPower")) + "\n");
               eegDataTxtArea.setCaretPosition(eegDataTxtArea.getText().length());
            }
            else
            {
               eegDataTxtArea.append(currentEEGReading + "\n");
               eegDataTxtArea.setCaretPosition(eegDataTxtArea.getText().length());
            }



            double attention = 0;
            double meditation = 0;
            if (currentEEGReading.contains("eSense"))
            {
               double delta = 0, theta = 0, lowAlpha = 0, highAlpha = 0, lowBeta = 0,
highBeta = 0, lowGamma = 0, highGamma = 0, poorSignalLevel = 0;
               currentEEGReading = currentEEGReading.replace("\"", "");
               currentEEGReading = currentEEGReading.replace("{", "");
               currentEEGReading = currentEEGReading.replace("}", "");
               currentEEGReading = currentEEGReading.replace("eSense:", "");
               currentEEGReading = currentEEGReading.replace("eegPower:", "");
```

```
String[] eegValues = currentEEGReading.split(",");
for (String eegVal : eegValues)
{
   String[] eegReadings = eegVal.split(":");
   double tempReading = Double.parseDouble(eegReadings[1]);
   switch (eegReadings[0])
   {
      case "attention":
         attention = tempReading;
         break;
      case "meditation":
         meditation = tempReading;
         break;
      case "delta":
         delta = tempReading;
         break;
      case "theta":
         theta = tempReading;
         break;
      case "lowAlpha":
         lowAlpha = tempReading;
         break;
      case "highAlpha":
         highAlpha = tempReading;
```

```
            break;
        case "lowBeta":
            lowBeta = tempReading;
            break;
        case "highBeta":
            highBeta = tempReading;
            break;
        case "lowGamma":
            lowGamma = tempReading;
            break;
        case "highGamma":
            highGamma = tempReading;
            break;
        case "poorSignalLevel":
            poorSignalLevel = tempReading;
            break;
        default:
            break;
    }
}

if (poorSignalLevel < ACCEPTED_SIGNAL_LEVEL)
{
    INPUT[0] = delta;
    INPUT[1] = theta;
```

```
        INPUT[2] = lowAlpha;
        INPUT[3] = highAlpha;
        INPUT[4] = lowBeta;
        INPUT[5] = highBeta;
        INPUT[6] = lowGamma;
        INPUT[7] = highGamma;

        fullGamma += highGamma;
        iterations = iterations + 1;
    }

}
```

MeditationNEuroskySocketClient

```
/**
 *
 * @author Achala
 */
public class MeditationNEuroskySocketClient {

    /**
     * Logger for this class
     */
    private static final Logger logger =
Logger.getLogger(MeditationNEuroskySocketClient.class);
    public static final String DEFAULT_HOST = "127.0.0.1";
    public static final int DEFAULT_PORT = 13854;

    private static MeditationNEuroskySocketClient INSTANCE = null;
    private String host;
    private int port;
    private boolean connected;
    SocketChannel channel;
    Scanner in;

    private MeditationNEuroskySocketClient() {

        this.host = DEFAULT_HOST;
```

```
    this.port = DEFAULT_PORT;
    this.connected = false;

}

public MeditationNEuroskySocketClient(String host, int port) {

    this.host = host;
    this.port = port;
    this.connected = false;

}

public static MeditationNEuroskySocketClient getInstance() {
    if (INSTANCE == null) {
        INSTANCE = new MeditationNEuroskySocketClient();
    }

    return INSTANCE;
}

public String getHost() {
    return host;
}
```

```
    public void setHost(String host) {
        this.host = host;
    }

    public int getPort() {
        return port;
    }

    public void setPort(int port) {
        this.port = port;
    }

    public boolean isConnected() {
        return this.connected;
    }

    public void connect(boolean enableRawData) throws IOException {

        if (!this.connected) {

            this.channel = SocketChannel.open(new InetSocketAddress(this.host, this.port));

            CharsetEncoder enc = Charset.forName("US-ASCII").newEncoder();

            String jsonCommand = "{\"timestamp\":true,\"enableRawOutput\": false,
\"format\": \"Json\"}\n";
```

```
            this.channel.write(enc.encode(CharBuffer.wrap(jsonCommand)));


            this.in = new Scanner(channel);
            this.connected = true;


           System.out.println("Meditation solution is ocnnected with the device");
        } else {


            System.out.println("Already connected");
        }


    }


    public void startRecording() throws IOException {
        if (this.connected) {
            CharsetEncoder enc = Charset.forName("US-ASCII").newEncoder();


            String jsonCommand =
"{\"startRecording\":{\"rawEeg\":true,\"poorSignalLevel\":true,\"eSense\":true,\"eegPow
er\":true,\"blinkStrength\":true},\"applicationName\":\"ExampleApp\"}\n";
            this.channel.write(enc.encode(CharBuffer.wrap(jsonCommand)));


            JOptionPane.showMessageDialog(null, "Start Recording");


        } else {
            logger.debug("startRecording meditation session () - Not connected...");
```

```
    }

}

public void stopRecording() throws IOException {
    if (this.connected) {
        CharsetEncoder enc = Charset.forName("US-ASCII").newEncoder();

        String jsonCommand = "{\"stopRecording\":\"ExampleApp\"}\n";
        this.channel.write(enc.encode(CharBuffer.wrap(jsonCommand)));

        JOptionPane.showMessageDialog(null, "Stop Recording");

    } else {
        logger.debug("stopRecording meditation session() - Not connected...");
    }
}



public boolean isDataAvailable() {
    if (this.connected) {
        return this.in.hasNextLine();
    } else {
        return false;
```

```
        }
    }

    public String getData() {
        return this.in.nextLine();
    }

    public void close() throws IOException {

        if (this.connected) {

            this.in.close();
            this.channel.close();
            this.connected = false;
        }
    }

}
```

```
    /**
     * Logger for this class
     */
    private static final Logger logger =
Logger.getLogger(MeditationNEuroskySocketClient.class);
    public static final String DEFAULT_HOST = "127.0.0.1";
    public static final int DEFAULT_PORT = 13854;

    private static MeditationNEuroskySocketClient INSTANCE = null;
    private String host;
    private int port;
    private boolean connected;
    SocketChannel channel;
    Scanner in;

    private MeditationNEuroskySocketClient() {

        this.host = DEFAULT_HOST;
        this.port = DEFAULT_PORT;
        this.connected = false;

    }

    public MeditationNEuroskySocketClient(String host, int port) {

        this.host = host;
```

```
    this.port = port;
    this.connected = false;

}

public static MeditationNEuroskySocketClient getInstance() {
    if (INSTANCE == null) {
        INSTANCE = new MeditationNEuroskySocketClient();
    }

    return INSTANCE;
}

public String getHost() {
    return host;
}

public void setHost(String host) {
    this.host = host;
}

public int getPort() {
    return port;
}
```

```
    public void setPort(int port) {
        this.port = port;
    }

    public boolean isConnected() {
        return this.connected;
    }

    public void connect(boolean enableRawData) throws IOException {

        if (!this.connected) {

            this.channel = SocketChannel.open(new InetSocketAddress(this.host, this.port));

            CharsetEncoder enc = Charset.forName("US-ASCII").newEncoder();

            String jsonCommand = "{\"timestamp\":true,\"enableRawOutput\": false,
\"format\": \"Json\"}\n";
            this.channel.write(enc.encode(CharBuffer.wrap(jsonCommand)));

            this.in = new Scanner(channel);
            this.connected = true;

           System.out.println("Meditation solution is ocnnected with the device");
        } else {
```

```
            System.out.println("Already connected");
        }

    }

    public void startRecording() throws IOException {
        if (this.connected) {
            CharsetEncoder enc = Charset.forName("US-ASCII").newEncoder();

            String jsonCommand =
"{\"startRecording\":{\"rawEeg\":true,\"poorSignalLevel\":true,\"eSense\":true,\"eegPow
er\":true,\"blinkStrength\":true},\"applicationName\":\"ExampleApp\"}\n";
            this.channel.write(enc.encode(CharBuffer.wrap(jsonCommand)));

            JOptionPane.showMessageDialog(null, "Start Recording");

        } else {
            logger.debug("startRecording meditation session () - Not connected...");
        }

    }

    public void stopRecording() throws IOException {
        if (this.connected) {
            CharsetEncoder enc = Charset.forName("US-ASCII").newEncoder();
```

```
        String jsonCommand = "{\"stopRecording\":\"ExampleApp\"}\n";
        this.channel.write(enc.encode(CharBuffer.wrap(jsonCommand)));

        JOptionPane.showMessageDialog(null, "Stop Recording");

    } else {
        logger.debug("stopRecording meditation session() - Not connected...");
    }
}



public boolean isDataAvailable() {
    if (this.connected) {
        return this.in.hasNextLine();
    } else {
        return false;
    }
}

public String getData() {
    return this.in.nextLine();
}

public void close() throws IOException {
```

```
        if (this.connected) {

            this.in.close();
            this.channel.close();
            this.connected = false;
        }
    }

}
```