

Implementation of Nine Men's Morris

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28. Juni 2015

Outline

- 1 Introduction
- 2 Milestones of Project
- 3 Software and Hardware Tools
- 4 Workflow
 - Basic requirements to achieve target
 - Main User Stories
- 5 Implementation phase
 - Program Architecture
 - Safety
 - Visual Analysis
 - Communication between Robot and Camera
- 6 Difficulties faced
- 7 Conclusion

Introduction

- KUKA Ibr iiwa 7.
- Game called Nine Men's Morris.
- Cognex Camera.
- Artificial Intelligence.

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Milestones of the Project

- Human vs KUKA robot.
- Robot can detect human moves and can perform its own moves wisely.
- Robot knows its turn after human.
- Through a camera robot interacts with real world.

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Software and Hardware Tools

- Robotic Arm LBR iiwa 7 R800 1 by KUKA Laboratories.
 - Sunrise Workbench.
- Cognex IS 7000 Camera.
 - Cognex In-Sight Explorer.
- Eclipse IDE for testing AI and Modbus TCP/IP Connection.
- GIT for version control.

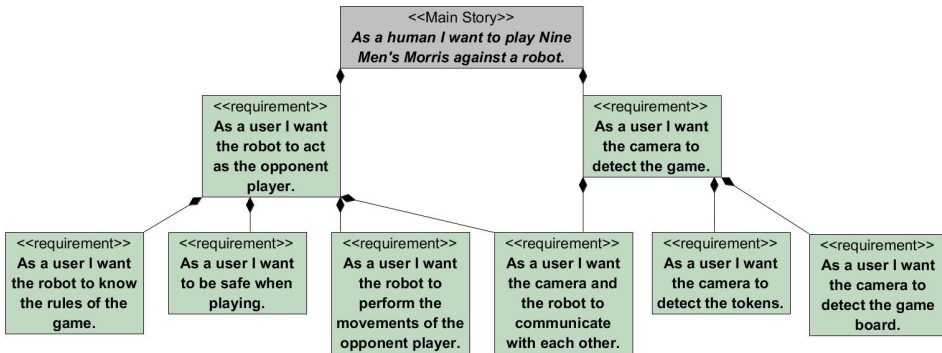
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Basic requirements to achieve target

- Understanding of Nine Men's Morris games rules.
- Getting started with some useful methods of the robot.
- Learn how to use the Camera.

Main User Stories

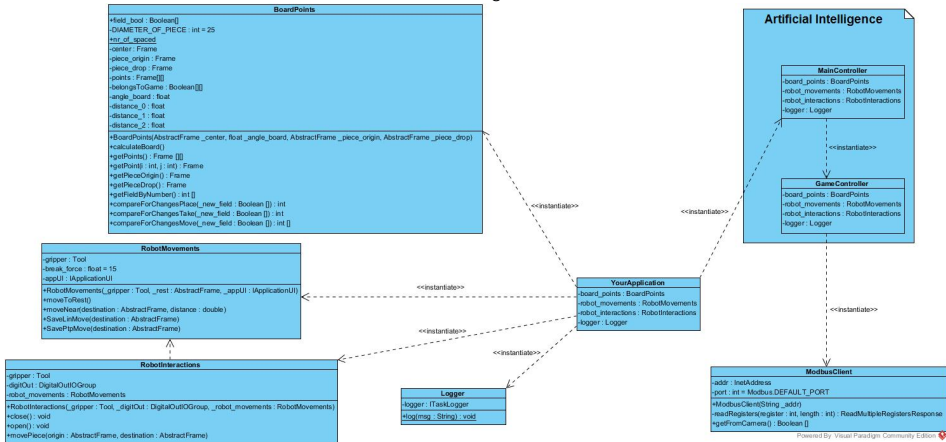


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Program Architecture

Class Diagram



Safety

Listing 1: Extract from the Class RobotMovements

```
/**
 * PTP Move method, which stops when a specific force is reached
 *
 * @param destination
 */
public void savePtpMove(AbstractFrame destination) {
    ForceCondition testForceCondition = ForceCondition.createSpatialForceCondition(
        gripper.getDefaultMotionFrame(), break_force);
    IMotionContainer movement = gripper.getDefaultMotionFrame()
        .move(ptp(destination)
            .breakWhen(testForceCondition)
            .setJointVelocityRel(0.5));
    IFiredConditionInfo firedCondInfo = movement.getFiredBreakConditionInfo();
    if (firedCondInfo != null) {
        ThreadUtil.millisSleep(1000);
        appUI.displayModalDialog(ApplicationDialogType.INFORMATION, "App Stopped...", "Continue");
        savePtpMove(destination);
    }
}
```

Listing 2: Call for save PTP Movement Method

```
robot_movements.savePtpMove(getApplicationData().getFrame("/piece_origin"));
```

Visual Analysis

File Edit View Sensor System Window Help

1. Starten
Verbindung herstellen
Bild einrichten
2. Werkzeuge einrichten
Teil suchen
Teil inspizieren
3. Ergebnisse konfigurieren
Eingänge
Ausgänge
Kommunikation
4. Fertig stellen
Blöck streifen
Job speichern
Job ausführen

PC
Sensor

45% Verfügbarer Jobumfang Offline

Palette

Name	Ergebnis
p_55	Vorhanden
p_55	X Nicht vorhanden
p_51	X Nicht vorhanden
p_43	Vorhanden
p_40	Vorhanden
p_53	Vorhanden
p_44	X Nicht vorhanden
p_43	Vorhanden
p_42	Vorhanden
p_36	Vorhanden
p_35	Vorhanden
p_34	X Nicht vorhanden
p_24	Vorhanden
p_23	Vorhanden
p_32	Vorhanden
p_22	X Nicht vorhanden
p_31	Vorhanden
p_30	Vorhanden
p_15	Vorhanden
p_13	X Nicht vorhanden
p_11	X Nicht vorhanden
p_06	X Nicht vorhanden
p_03	Vorhanden
p_00	Vorhanden

Rate: 50.0% (12)
Zeit: 3.5 ms

Kommunikation

OPC
EasyView
FTP
Modbus-TCP-Server

Formatierungseingabedaten

Startadresse	Name	Datentyp	Größe	Wert
30010	p_00.Ergebnis	Zeichenfolge	1	Vorhanden
30011	p_03.Ergebnis	Zeichenfolge	1	Vorhanden
30012	p_06.Ergebnis	Zeichenfolge	1	Nicht vorhanden
30013	p_11.Ergebnis	Zeichenfolge	1	Nicht vorhanden
30014	p_13.Ergebnis	Zeichenfolge	1	Nicht vorhanden
30015	p_15.Ergebnis	Zeichenfolge	1	Vorhanden
30016	p_22.Ergebnis	Zeichenfolge	1	Nicht vorhanden

Datentyp:

30010 566f Vo
30011 566f Vo
30012 0066 Ni
30013 4a59 Ni
30014 4a59 Ni
30015 566f Vo
30016 4a59 Ni
30017 566f Vo
30018 566f Vo

Meldungsgröße (Wörter): 24

Communication between Robot and Camera

Modbus/TCP

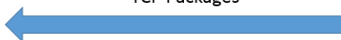


Modbus/TCP Client

ReadMultipleRegistersRequest(register, length);



TCP Packages



```
30010 566f Vo
30011 566f Vo
30012 4e69 Ni
30013 4e69 Ni
30014 4e69 Ni
30015 566f Vo
30016 4e69 Ni
30017 566f Vo
30018 566f Vo
```



Modbus/TCP Server

[CameraIP]:502

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Difficulties faced during the project

- Understanding of robotics
 - Robot movement limitations
 - Coordination transformations
- Understanding of AI.
- Recognition by the camera.
 - Game board alignment.
 - Token recognition
- Communication of robot and camera.

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Conclusion

- Human can play Nine Men's Morris against the robot.
- Possible Improvements:
 - 1 Better cheat handling
 - 2 Board orientation and location
 - 3 Choosing token color and starting player

Thank You