Project plan
Modeling and control of an industrial robot

Version 1.0

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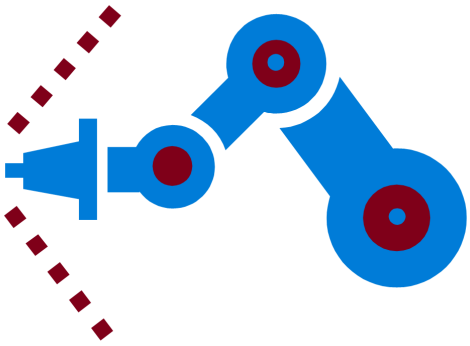

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Document History

Version	Date	Changes made	Sign	Reviewer
0.1	2011-09-19	First draft.	AP	Patrik Axelsson
0.2	2011-09-20	First revision.	GA	Patrik Axelsson
0.3	2011-09-21	Second revision.	GA	Patrik Axelsson
1.0	2011-09-22	First version.	AP	Patrik Axelsson

Contents

1 Customers

The customers of the project are Mikael Norrlöf at ABB Robotics and Johan Sjöberg at ABB Corporate Research.

2 General description of the project

This section contains information about the aim of the project, the documents it contains and the restrictions it has.

2.1 Purpose and objectives

The purpose with the project is to apply knowledge from previous courses in an industrial professional manner. The project is supposed to be implemented in such a way that the members of the project group will develop and consolidate knowledge in implementing a project according to the LIPS-model [1] and integrate knowledges from control theory, modeling and simulation, signal processing, programming etc.

The goal is to control an industrial robot, which can be divided into:

- Develop a kinematic model
- Develop a flexible dynamic model
- Control the robot
- Connect the hardware with Matlab/Simulink
- Investigate deficiencies with the current design for future development

2.2 Deliveries

The following deliveries are included in the project. The dates are preliminary.

Delivery	Decision point	Date	Type of delivery
Requirements specification	BP2	2011-09-22	Electronic
Project plan with time plan	BP2	2011-09-22	Electronic
System sketch	BP2	2011-09-22	Electronic
Design specification	BP3	2011-10-10	Electronic
Test plan	BP3	2011-10-10	Electronic
Functionality	BP5	2011-11-25	Electronic
Test protocol	BP5	2011-11-25	Electronic
User guide	BP5	2011-11-25	Electronic
Meet requirements	BP5	2011-11-25	Oral presentation
Technical report	BP6	week 49	Electronic
After study	BP6	week 49	Electronic
Poster presentation	BP6	week 49	Presentation
Home page	BP6	week 49	Web
Film presentation	BP6	week 49	Presentation/Web

2.3 Restrictions

The control of the robot will only be made with respect to the first three axes. It should not be investigated whether it is better to use a different programming language. Furthermore, education for the customer will not be included in the project, except for a user guide.

3 Phase plan

3.1 Before project

- Make sure everyone knows their part in the group
- Write a project specific paper, which describes the overall project
- Uphold a contract with certain rules for everyone to follow
- Figure out what tests and experiments that needs to be done
- Understand how the robot works
- Gather necessary information to be used later on

3.2 During project

- Have meetings on a regular basis
- Report the amount of time each group member has worked on the project every week
- Define more specific tests and experiments
- Perform tests and experiments
- Develop a kinematic model for the system
- Develop a dynamic model for the system
- Simulate the system
- Design and simulate controllers
- Implement the controller on the real robot
- Test functionality

3.3 After project

- Deliver the product to the client
- Make an evaluation test to make sure it works as intended
- Go through the list to see if the requirements are met
- Present the result to others
- Make a video about the project
- Make an after study

4 Organisation plan for the whole project

This chapter specifies how the organisation of the project is structured. The different roles and their responsibilities in the project group are also presented.

4.1 Terms and conditions for cooperation within the project group

The total amount of work will be divided among the group members so that each member contributes with equal amount, 240 h per person. All group members must also attend all the meetings. They are supposed to and must notify the project leader in case they will be late or if they cannot attend. All meetings are time limited to two hours but may be shorter. In case of late arrival, for each five minutes the group member receives a warning. If a group member has more than two warnings the member must bake, not buy, buns or cookies for the next meeting. If a member continues to be late or misbehaves in general, the member will be notified and confronted. The orderer will be notified if the member continues the misbehavior.

The main form of communication within the project group is email.

4.2 Definition of work contents and responsibilities

4.2.1 Project manager

The project manager has the ultimate responsibility for the group. The project manager is responsible for the group meetings, that everything goes according to the schedule and to make sure everyone works towards a common goal.

4.2.2 Documents

The document manager has the utmost responsibility of all the documents and will also be the one who hands them in to the orderer. The document manager is also responsible to create templates for different documents and how they are written in Latex. The document manager will also manage the SVN server.

4.2.3 Design

The design manager is responsible to implement the robot model into Matlab and Simulink. The design manager is also responsible for the controllers that will control the robot and the user interface.

4.2.4 Mechanical modeling

The mechanics design manager is responsible of the system identification and will also make sure the kinematic and dynamic models of the robot are correct.

4.2.5 Tests

The test manager has the utmost responsibility when it comes to the hardware required to conduct tests. The test manager will write the test plan, appoint times for the tests and must make sure the required hardware are present when the testing is supposed to occur. The test manager has the utmost responsibility that all requirements are tested.

4.2.6 Information

The information manager is responsible for all the information concerning the project. The information manager will manage the web page and is responsible for the video clip that will be made. The information manager is also responsible for the poster and the presentation of the project.

5 Documentation

- All the documents will be handled by the responsible person
- The English language will be used for most of the documents
- A document will only be made public, when all demands are met for a specific document
- The project manager has the ultimate responsibility for every document and its contents

6 Development methodology

The project will follow the LIPS-model and all documents will be written in English in already existing templates. All documents will be stored and versioned at the group's SVN-account.This allows all group members to have easy access to all files from home.

7 Reporting plan

The reporting during the project consists of regular time sheets with a associated revised schedule and status reports. The reporting are prepared by each group member to the project manager, who sends all reporting to the orderer once a week.

7.1 Time sheet

A common time sheet will be consolidated by the project manager, and send to the orderer every Monday at the latest at 5 pm. The project manager is responsible for follow up and revise the schedule if necessary.

7.2 Status report

The project manager is responsible to put together a status report and send to the orderer each week together with the time sheet.

8 Meeting schedule

Project meetings will be held at least once a week and take a maximum of two hours each time to complete. At the meeting the group will book the next meeting. The project manager is responsible to convene the group and write an agenda. The agenda must be

sent via email at the latest 24 hours before the meeting, the group members must therefore submit any decision points prior to this. A protocol is written by a secretary and adjusted by an adjuster. Both of these will be selected at the beginning of each meeting and the roles will rotate between the project members.

9 Resources

9.1 Staff

There are eight students who will work on the project, each person is required to take part in the project. The group has also advisors to ask during the course.

9.2 Material

The material which will be used, is handed out by ISY and IEI and consists of the robot, specific software, computers and experimental equipment.

9.3 Facilities

The group has various rooms which can be used during the course of the project. One of the rooms are provided by ISY and is a project room shared with another group. IEI also provide a laboratory room where the robot is.

9.4 Economy

The group doesn't have real money to use on their own, but if some extra material is needed, within certain limits, it will be provided by ISY. The project do however have a time limit of 240 h per person, total for the group is 1920 h.

10 Milestones and decision points

Milestones are short-term goals to work towards, so that the group get a clear confirmation on the status of the project, whereas decision points are fixed and dates are determined by the orderer.

10.1 Milestones

All milestones are dated and placed in the time schedule. They are also clearly measurable and give therefore a good indication of whether the project is progressing as planned.

Nr.	Description	Approximate date
1	Decision point 2 done	2011-09-21
2	Create a forward kinematic model	2011-09-21
3	Control the robot manually	2011-09-30
4	Create a rigid dynamic model	2011-09-30
5	Create a inverse kinematic model	2011-10-07
6	Test plan done	2011-10-07
7	Design specification done	2011-10-07
8	Dynamic model with unknown parameters	2011-10-14
9	Verified and simulated models	2011-10-28
10	All unknown parameters identified	2011-11-02
11	Control system finalized	2011-11-18
12	Trajectory plan finalized	2011-11-18
13	Robot finalized	2011-11-21
14	User guide done	2011-11-22
15	Movie done	2011-11-24
16	Homepage done	2011-11-24
17	Poster presentation done	2011-11-24
18	After study done	2011-11-24
19	Technical documentation done	2011-11-24
20	Decision point 6 done	2011-12-05

10.2 Decision points

The decision point below are numbered as in the LIPS-model. The missing decision points are not used in this project.

Nr.	Description	Date
2	Approval of project plan with time plan, requirements specification and system sketch	2011-09-22
3	Approval of design specification and test plan	2011-10-10
5	Approval of functionality, test protocol and user guide. Presentation of all met requirements	2011-11-25
6	Approval of technical report, after study, poster presentation, home page and movie.	week 49

11 Activities

In the following table, all the activities in the project are listed. Education in the robotics field is included in the different activities.

Number	Activity	time(h)
1.	**Before project (prepare necessary documents)**	80
1a.	Requirements specification	35
1b.	Project plan	20
1c.	Time plan	13
1d.	System sketch	11
1e.	Group contract	1
2.	**Kinematic model**	120
2a.	Create a forward kinematics model	10
2b.	Create an inverse kinematics model	20
2c.	Implement the forward kinematics	25
2d.	Implement the inverse kinematics	25
2e.	Validate and test the kinematic models	40
3.	**Dynamic model**	270
3a.	Create a rigid dynamic model	30
3b.	Model the gearbox	30
3c.	Model the friction	30
3d.	Gather data for system identification	30
3e.	Identify the unknown parameters	30
3f.	Validate the identified parameters	30
3g.	Implement the model	50
3h.	Validate and test the dynamic model	40
4.	**Connect the two kinematic and dynamic models**	35
5.	**Compare the simulated result with the real robot**	40
6.	**Interface**	85
6a.	Connect the robot with Matlab and Simulink	45
6b.	Implement the user interface	40
7.	**Control systems**	280
7a.	Design reference angles generator for joint control	10
7b.	Design feedback control for the joints	30
7c.	Design feed forward control for the joints	30
7d.	Translate room coordinates to joint angles for trajectory plan	5
7e.	Design time aspects for trajectory plan (distance, velocity etc.)	50
7f.	Translate tool speed to angular velocities	45
7g.	Model the relationship between motor current/voltage and torque	30
7h.	Create a current/voltage controller	30
7i.	Test the control system	50
8.	**Final validations**	70
9.	**Documentation**	455
9a.	Design specification	75
9b.	Test plan	40
9c.	Technical documentation	140
9d.	User guide	30
9e.	Home page	30
9f.	Movie	30
9g.	Poster	20

9h.	Poster presentation	30
9i.	After study	30
9j.	Compilation of documents e.g time sheets and status reports	30
10.	**Meetings**	280
10a.	Project meetings	133
10b.	Orderer meetings	62
10c.	Customer meetings	55
10d.	Advisor meetings	30
11.	**Other activities**	205
11a.	Lectures	28
11b.	Self studies and education	50
11c.	Re-planning	10
11d.	Reserve time	117
	Total time	1920

12 Changes

If the project for some reason is delayed so that all requirements cannot be met, the project manager has to negotiate a new requirements specification with the customer.

If a project member wants to change or add something to the project, this has to be discussed and decided on a meeting.

13 Quality plan

13.1 Audits

All documents will be supervised by the responsible for the documents and the project leader. Everyone else is responsible for what they do in terms of functionality, when it comes to programming, and various designs.

13.2 Test plan

Tests and experiments will be done on a regular basis, to make sure everything works as intended. All tests must follow the test plan, which verifies all requirements.

14 Risk analysis

One risk is that a group member by any acceptable reason, e.g. longtime sickness, cannot complete an assignment he/she has assumed. In this case, the group has to allocate the assignments so that the requirements still can be met, or the requirements has to be renegotiated. If a hardware error occurs, a discussion with the orderer decides what to do. To avoid software errors, all software should be saved on multiple computers and on the SVN-account.

15 Priorities

The requirements specification is constructed with three different levels of priorities. Requirements with priority 1 are requirements that have to be fulfilled and must be renegotiated with the customer in case there is not enough time. Priority 2 are more optimistic requirements that will be fulfilled if there is enough time to complete them. Priority 3 requirements are very optimistic and will only be attempted to fulfill if there is plenty of time left.

16 Project closure

The project ends when the after study is approved. The project closes with a project conference where the poster is presented. All keys and computers should be returned as soon as possible after the end of the project.

17 References

[1] Svensson, Tomas & Krysander, Christian (2007), Projektmodellen LIPS, Version 1.3, LiTH, Linköping.