How to write a protocol for the MSc laboratory course at the IST ⋆

Kimon Beyer, Yves Gaßmann, Justin Buhl

Abstract: In diesem ersten Protokoll handelt es sich um eine Zusammenfassung des Vorgehens der Gruppe AWe1 des Praktikums "Konzepte der Regelungstechnik" am Institut für Systemtheorie und Regelungstechnik der Universität Stuttgart. In diesem ersten Protokoll werden die Ergebnisse von L1 und H1 dargestellt, wobei sich der erste Teil um L1 handelt und der zweite Teil um H1. Während sich L1 mit der Betriebnahme des Versuchsstandes beschäftigt, wird im anschließenden H1 Teil die Modellierung des 3DOF Helikopters durchgeführt, mit abschließender Respektive auf die in L2 zu erledigende Modellidentifizierung.

1. EINLEITUNG

In diesem Protokoll werden die Ergebnisse der ersten Laboraufgabe (L1) und der ersten Hausaufgabe (H1) des Praktikums "Konzepte der Regelungstechnik" am Institut für Systemtheorie und Regelungstechnik der Universität Stuttgart zusammengefasst. Ziel von L1 ist es, den Versuchsstand in Betrieb zu nehmen und die grundlegenden Funktionen zu verstehen. H1 konzentriert sich auf die Modellierung des 3DOF Helikopters, um eine Grundlage für die anschließende Modellidentifizierung in L2 zu schaffen. Beim zu regelnden Versuchsstand handelt es sich um einen 3DOF Helikopter, der entlang seiner Hauptachsen/Gelenkachsen (Travel angle, elevation angle, pitch angle) bewegt werden kann. Ziel des Praktikums ist es eine vorgegebene Trajektorie innerhalb einer gewissen Zeit abzufliegen und dabei die jeweiligen Beschränkungen einzuhalten.

Zur Steuerung stehen zwei 12V Elektromotoren zur Verfügung, über die der elevation Winkel gesteuert werden kann, wobei eine Spannungsdifferent an beiden Motoren zur Ansteuerung des Pitch Winkels und somit auch des travel Angels verwendet wird. Jede der Achsen verfügt dabei über Encoder, über die die relativ zur Ausgangsposition Winkelinkrement gemessen werden kann. Die Ansteuerung der Motoren, sowie das Auslesen der Encoder erfolgt über die "Quanser Quarc" Schnittstelle, die eine Erweiterung für Matlab/Simulink darstellt. Diese Schnittstelle ermöglicht es, Simulink Modelle in Echtzeit auf dem PC auszuführen und die Signale über jeweilige Blöcke anzusteuern und auszulesen.

2. PURPOSE OF PROTOCOL

The protocol has two main objectives: Making your approach or results repeatable and enabling your supervisor to evaluate your results.

First, other people need to be able to reproduce the experiment and come to the same results. Therefore, the approach has to be documented such that the results can be repeated based on the given information. This is especially required in industry, whenever other people build up on your work. For this laboratory course, imagine that based on your protocol the next year students should come up with an improved solution. Furthermore, a good documentation also enables you to recapitulate your line of action after some time - e.g. when writing the final protocol mentioned in Section 8. The master laboratory course with one detailed project is an excellent opportunity to learn documenting your work. Thus, we encourage you to document *while* working and not only afterwards. This can be achieved by commenting your Matlab-files or making all required notes while being in the laboratory.

Second, the reader of the protocol wants to assess your work. This should enable your supervisor not only to check your work but moreover to give specific feedback and helpful hints.

3. STYLE

To serve the above stated purpose of the protocols, we demand a high quality, i.e., well structured, a comprehensible line of thought, and well selected figures. Basic rules how to write in a comprehensible style can be found in the slides of the Proseminar course, which are in German. A selection of the appropriate slides can be found in Ilias. More detailed and English guidelines appeared in IEEE Control Systems Magazine [2004].

As we require a high quality of the protocols, we do not limit the number of pages. As a guideline, three pages is a reasonable length. But the protocol must contain all relevant information.

4. LATEX

The protocols have to be typeset with LaTeX. A good German introduction to LaTeXcan be found in [Jürgens and Feuerstack, 2011]. An alternative in English is [Oetiker et al., 2011]. A short guide concerning the mathematical part is given by [Downes, 2002].

5. SUBMISSION

Two files have to be submitted to the Praktikumskoordinator until 11:59pm four days before the laboratory by uploading them into Ilias:

⋆ Institute for Systems Theory and Automatic Control, University of Stuttgart, Germany. *http://www.ist.uni-stuttgart.de*

- A pdf-file of the protocol and
- a zip-file containing all the relevant Matlab-files.

Every student has to be *responsible* for the protocol and the zip-files *once* during the course.

The protocol for every laboratory day has to contain

- a result protocol of the last laboratory, if applicable,
- a protocol of the preparation and
- a working plan for the next laboratory.

A template for the working plan can be found in Table 1. Of the last laboratory day, a result protocol has to be written which is due one week after the laboratory.

To make your approach or results repeatable, comment all your Matlab-scripts and Simulink-files appropriately - preferably while working with them. Decide, which files and maybe also measurement data is necessary to repeat your results. Then, put all necessary files into one zip-file and upload it into Ilias. In the protocol you should reference the files where the information is only needed for repeatability. Furthermore, you should refer to the files while explaining your procedure. Thus, you don't have to include all information into the protocol.

You can write either in German or English. If you write in German, it is a good idea to include the packages ngerman, inputenc, and fontenc in the preamble of your tex-file.

6. STRUCTURE

In the title include your group description and the task the protocol is about. The group description follows the syntax $IDDN$-T with $I \in \{A, B\}$ being the cycle number, $DD \in \{Mo, Tu, We, Th\}$ the day, $N \in \{1, 2, 3, 4\}$ the group number, and $T \in \{1, 2, 3, 4, 5\}$ the task number. For example AMo1-1. Include all group members as authors. Underline the corresponding author. In the abstract, you should summarize the result within up to three sentences.

The structure on the section level has to be decided depending on the tasks. For the main sections, the structure can be similar to the problem-solving process:

- *Work task* explaining the task and the goal.
- *Solution approach* describing the chosen solution to allow the reader to repeat and assess the solution.
- *Result* containing the observations and justified conclusions.
- *Critical comments* evaluating the approach including a comparison with the working plan. Furthermore the pros and cons should be discussed.

7. FIGURES AND GRAPHICS

All figures should be created as done in the Matlab-script "plotFigureTest.m" which can be found in Ilias. By following the procedure, the axis labels and ticks are in an appropriate size, the same LaTeX-font is used, and the line thickness is adjusted resulting in a formally excellent figure. If you have plots in Simulink, export the data and create a Matlab figure. To label the axis, use words and not symbols. Write units in parentheses. E.g., write "Control input u (V)". An easy and nice-looking way for the legend

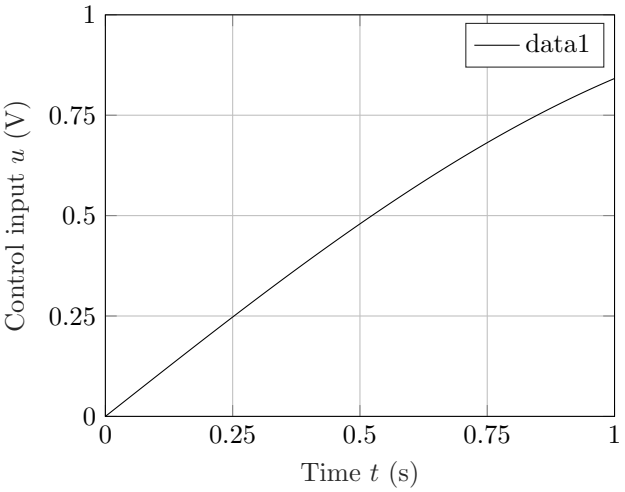

Fig. 1. Exemplary Matlab figure. The exemplary signal is plotted in (—).

is to include it into the caption of the figure. See the tex-code for more details.

Graphics for the protocol can be made for example with the Open Source vector graphics editor Inkscape. Details can be found on `http://inkscape.org/`.

8. FINAL PROTOCOL

At the end of the course a protocol over the whole laboratory has to be written. This final protocol may have up to 8 pages. The final protocol may be based on your other protocols and you can reuse parts of the other protocols. But the final protocol has to be self-contained and needs to have a comprehensible line of thought.

The purpose of the final protocol is that the reader gets an idea of your whole solution. Therefore, it should contain the results of your work. To understand the results, you should also include your approaches on a more abstract level. For you, the final protocol is a chance to reflect the laboratory as a whole.

REFERENCES

Jürgens, M. and Feuerstack, T. (2011). LaTeX-eine Einführung und ein bißchen mehr.... Fernuniversität in Hagen, A/026/0911. Available online from `http://www.fernuni-hagen.de/imperia/md/content/zmi_2010/a026_latex_einf.pdf`.

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Downes, M. (2002). Short Math Guide for LaTeX. American Mathematical Society. Available online from `ftp://ftp.ams.org/pub/tex/doc/amsmath/short-math-guide.pdf`.

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Table 1. A Working Plan Template.

Time	**Duration**	**Goal**	**Task**	**Preparation**
14:00	30 min.	Test File to actuate motor	Create Quarc Simulink File	Read Quarc documentation