Bachelor's thesis

Czech Technical University in Prague

F3

Faculty of Electrical Engineering
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Extraction of features from moving garment

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Acknowledgement / Declaration

Foremost, I would like to thank to Ing. Pavel Krsek, Ph.D. ...

Prohlašuji, že jsem předloženou práci vypracoval samostatně a že jsem uvedl veškeré použité informační zdroje v souladu s Metodickým pokynem o dodržování etických principů při přípravě vysokoškolských závěrečných prací.

V Praze dne 5. 5. 2013

....

Abstrakt / Abstract

Tento...

Klíčová slova: dynamický model; model oděvu, textilie; extrakce příznaků; 3D obraz; silueta.

Překlad titulu: Získání příznaků z obrazu pohybující se látky

This...

Keywords: dynamic model; garment model; feature extraction; 3D image; silhouette.

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Chapter 1
Introduction

1.1 Motivations

This bachelor thesis is part of Clothes Perception and Manipulation project (CloPeMa, 2012-2015) funded by the European Commision. CloPeMa is research project which aims to advance the state of the art in the autonomous perception and manipulation of fabrics, textiles and garments. The CLoPeMa robot will learn to manipulate, perceive and fold a variety of textiles [1].

1.2 Goals

The whole CloPeMa project is based on the manipulation of clothes (garments). Simplified dynamic physical model of real garment should be useful for these manipulations e.g. for simulating movement or collision detection. This is usefull for example for simulating or for counting model collisions. For creating virtual model of garments is important to have their parameters. This thesis has goal to design method of measurement and extraction of image features for obtaining parameters which will lead to construct the model.

1.3 The State of the Art

The main sphere of using dynamic simulation of garment is computer graphic. These simulations are mainly for a realistic look, but not for real dynamic physical behavior of garment [2] (including modern metod of simulating [3–4]). Simulation of garment from real physical parameters deals e.g. [5]. Obvykle se modeluje takto [6–11]. In the science and industry exist several measuring techniques which is used to find elementary parameters of fabrics e.g. KESF, FAST or FAMOUS. Kawabata's Evaluation System of Fabric (KESF) is used to get the mechanical properties of the clothes. KESF contains a several equipments for measure these properties. KESF was developed for mass-spring method. The method need a piece of fabric (size depends on the current implementation) for the measurement. On this sample is applied a force in the different directions and ways (depends on current physical property). The KESF produces curves depending on the applied force. The Kawabata instruments test with high accuracy: compression, pure bending rigidity, roughness, shear, surface friction and tensile [12–14].

Very similiar to the Kawabata's System is the most popular commercial systeme - Fabric Assurance by Simple Testing (FAST). Both systems were designed to measure fabric mechanical properties at low-stress level, but both systems use different testing principles. KESF system measure deformation and recovery behaviour while FAST system determines deformation level at a single point on the deformation curve, so FAST system cannot measure hysteresis [14]. Another differences are that the KEFS use different equipment for each property. The FAST are more properties measure on one equipment, so the number of equipments are reduced [13].

The Fabric Automatic Measurement and Optimisation Universal System (FAMOUS) is faster method of ”manual” measurement. A complete suite of measurement take less than five minutes [13].

These measuring techniques were designed for using in textile and clothes industry, but also are used for computer graphics simulation of garments. These techniques measure e.g. flexural rigidity, shear, surface, compression or tensile properties, but need tens of measurement equipments and process to acquire parameters process takes from a few minutes (FAMOUS) up to units of hours (KESF). [12, 15–16, 13]. While existing methods give excellent results and detailed description of substances, but do not tell us anything about the whole garment. Moreover, these methods are slow and expensive.

There are also methods of estimating parameters based on extraction features from video. In the method is on the fabric projected a structured light pattern of horizontal stripes. [17]

- odhadování parametrů z videa [17]
- Zmínit použití Mocapu [18]

Therefore, we propose which parameters we will need for build a simple dynamic physical model and we propose easiest way to obtain these parameters. We think that for such a simplified model, the parameters are well estimated from a moving garment, for which this model we want to build. This movement will cause the robot and we will capture the movement according to available equipment of robot (chap. 2.1), so we use the RGB camera and rangefinder.

Chapter 2
Description of Workplace and of the Software

[sec:workplace] 2.1 Workplace

2.1.1 Manipulator

The base is composed of two robotic manipulator arm Motoman MA1400. First arm is called as `r1` (or also appears like `R1`). Second arm is similarly marked `r2` (`R2`). The arms `r1` and `r2` are placed on the turntable. The turntable is rotated about an axis known as `external axis` (or `Ext.` or possibly as axis `13`). Location of arms and rotating around the `Ext.` axis can be better seen from (figure 2.2).

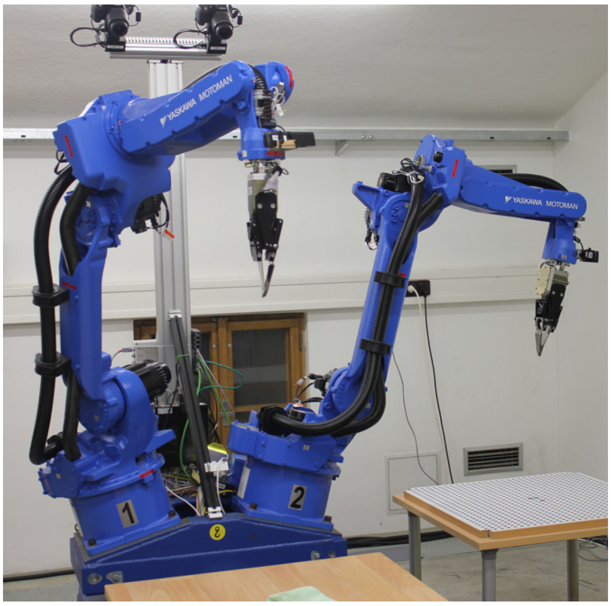
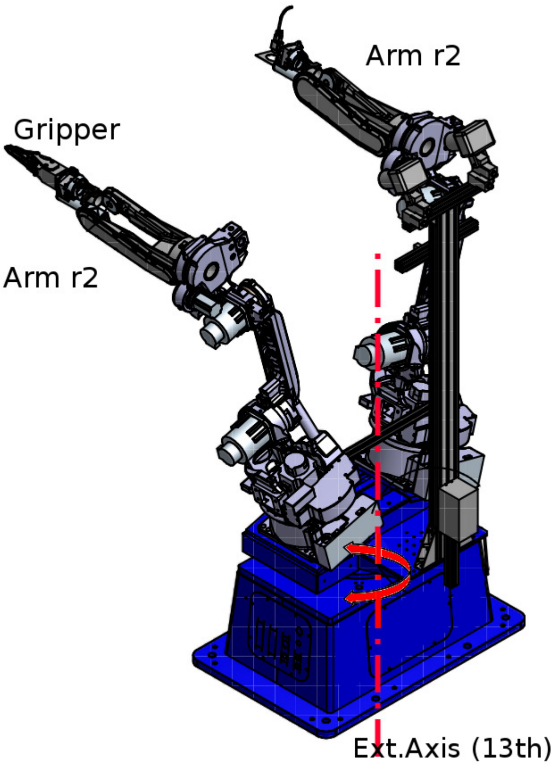


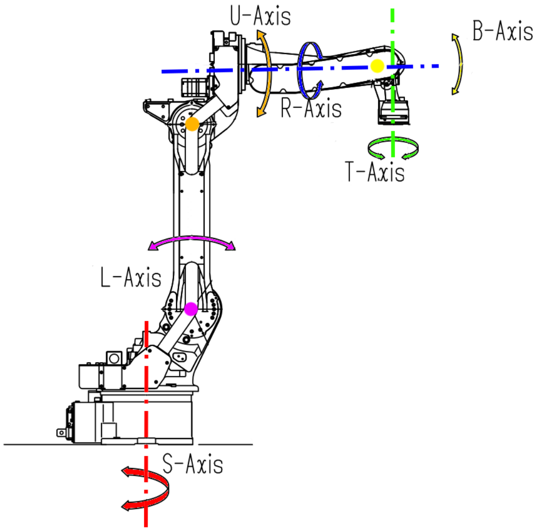
Figure 2.1. Manipulator of CloPeMa project location at CTU

Each arm of manipulator has 6 rotation axes. The axes are labeled according to the manufacturer with the letters `S`, `L`, `U`, `R`, `T` and `B` (figure 2.3). This is description of single the arm of robot. Numeral is added to identify the arms e.g. `S` axis located on the arm `r1` will be called `S1`, etc. Similarly to the designation of arms we can meet even using small letters (eg.: `s1`).



[fig:motomanAndTable]

Figure 2.2. Identification of arms and location of external axis.



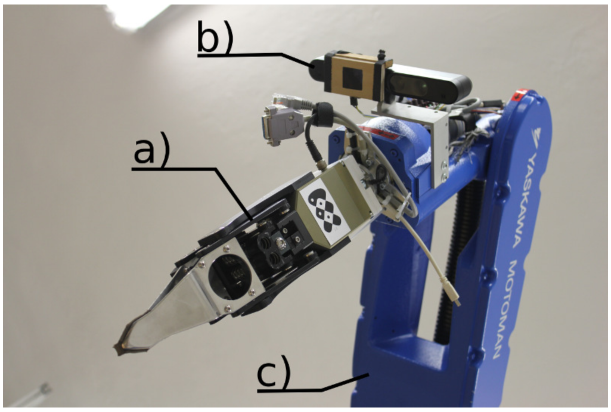
[fig:motomanAxis]

Figure 2.3. Description of robotic arm Motoman MA1400 - axis.

2.1.2 End effector

Each of arms `r1` and `r2` are ended with eletricly controlled grippers. (figure 2.4). Grippers are designed for grasping of garment.

- Rozvést
- Popsat prsty



[fig:gripper]

Figure 2.4. End effector (gripper). a) gripper, b) sensor Asus Xtion, c) end of arm on which the gripper is mounted.

[secc:camera]

2.1.3 Sensors

- Robot je vybaven řadou senzorů...
- Popsat více senzorů (alespoň základně)
- Pro řešení vybrat důležité
- Nepoužívat camcorder

The next important part of manipulator is camcorder Asus Xtion. This camcorder is able to record RGB images and depth maps. Camcorder mounted on the arm `r1` is called `xtion1` and camcorder mounted on the arm `r2` is called `xtion2`. Position of cameras is shown in figure 2.4.

2.2 Software

Robot is operated using Robot Operating System (ROS). ROS is an open-source system. ROS is not an operating system in the traditional sense of process management and scheduling. Rather, it provides a structured communications layer above the host operating systems of a heterogenous compute cluster [19]. In CloPeMa project is used Ubuntu (Debian-based Linux OS) as a host operating system.

[secc:rosintro]

2.2.1 Robot Operating System

A system built using ROS consists of a number of processes, potentially on a number of different hosts, connected at runtime in a P2P topology. The fundamental concepts of the ROS implementation are **nodes**, **messages**, **topics**, and **services**.

Nodes are processes that perform computation. ROS is designed to be modular. A system is typically comprised of many nodes. In this context, the term ”node” is interchangable with ”software module”. Nodes communicate with each other by passing messages. A **message** is a a strictly typed data structure. Standard primitive types (integer, floating point, boolean, etc.) are supported. Arrays of primitive types and constants are supported too. Messages can be composed of other messages, and arrays of other messages, nested arbitrarily deep. A node sends a message by publishing it to a given **topic**. A node that is interested in a certain kind of data will subscribe to the appropriate topic. There may be multiple concurrent publishers and subscribers for a single topic, and a single node may publish and/or subscribe to multiple topics. In general, publishers and subscribers are not aware of each others existence [19].

Although the topic-based publish-subscribe model is a flexible communications paradigm, its "broadcast" routing scheme is not appropriate for synchronous transactions, which can simplify the design of some nodes. In ROS, we call this a **service**, defined by a string name and a pair of strictly typed messages: one for the request and one for the response. This is analogous to web services, which are defined by URIs and have request and response documents of well-defined types. Note that, unlike topics, only one node can advertise a service of any particular name: there can only be one service called "classify imag", for example, just as there can only be one web service at any given URI [19].

- Mírně zkrátit - odstranit příklady

In the ROS are designed a large number of tools e.g. for get and set configuration parameters, for plotting or visualisation. For this project is important a **rosbag tool**. This is basucally a set of tools for recording from and playing back to ROS topics [20]. With help of this tool we can record choosen topics, including timestamp, to the `*.bag` file.

- Rozvést co dělá rosbag tool, 14:45-16:10

Chapter 3
Way of getting data

[sec:requirements]
3.1 Goals of experiment

- zaměnit správná slovíčka
- zlepšit překlad

The requirement on the experiment is to obtain mathematical features by which could be used to estimate the parameters of the dynamic physical model of garment. These symptoms we determine by tracking hanging garment. Movement of hanging garment will cause the movement of the manipulator gripper that holds garment. Based on the sensors that we have available, we have chosen:

- simplest movement, which we think could give us the necessary data to obtain the parameters of the dynamic model of garment **lepší překlad - zjednodušit**. This movement is the movement of garment in the plane, ideally excited by moving gripper of a garment in a straight line (line segment).
- two types of motion tracking

a) with standart RGB video camera tracking a silhouette of garment against the constant background when garment is moving **perpendicular to the optical axis**.
b) with rangefinder tracking when garment is moving **along the optical axis**.

3.2 Realisation

Already during the first experiments, we found that the dynamics of the manipulator is not fast enough to perform the desired movement of the gripper with garment necessary speed. (section ??). However, it is possible to achieve the required speed when the motion will be based on a single joint. That is why we had to limit the movement of the gripper with the garment implemented that the movement of gripper along line segment is approximated by moving the gripper on the part of the circle. Another limitation is the spatial limitation, such that it is not possible to place the camera `xtion` in the appropriate position to capture RGB images (ie, the position where the gripper with garment moves perpendicular to the optical axis) and then the camera `xtion` move to position suitable for capturing depth maps (ie, the position where the gripper with garment moves along the optical axis). These restrictions are solved via camera `xtion` position (ie the position of the arm with the camera) which is fixed in the same position for record RGB videos as well as for sensing depth maps. Instead, the arm with garment makes a move of gripper with two different ways so that the movements fulfilled the conditions for sensing with each sensors (chap. ?? — perpendicular position vs. along the optical axis).

- Přidat obrázek k odstavci realisation
- Více rozvést odstavec 18:50-21:20
- Obrázek zesvětli a popsat i gripper 21:20-22:30

3.3 Positions of Manipulator

- Rozdělit podkapitoly 3.3 a 3.4 jinak; 22:30-24:40, 25:25-30:00

3.3.1 Arm with Sensors

The record is captured with camera `xtion1` mounted on the arm `r1`. The arm `r1` moves into position where the optical axis of the camera heads horizontally. Simultaneously is the optical axis of the camera oriented towards arm `r2` (figure 3.1).

[fig:OptOsa]

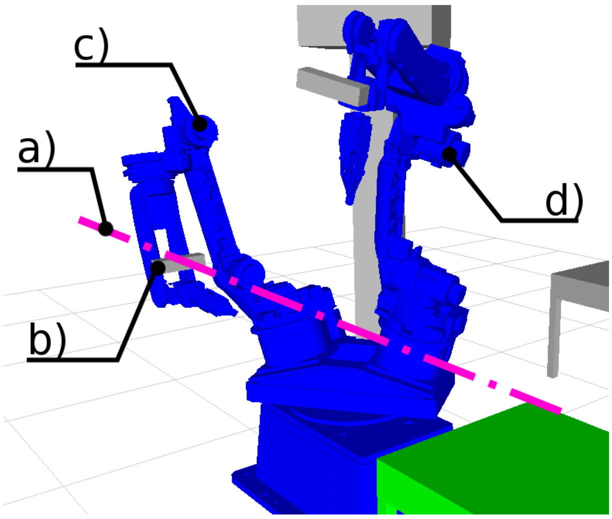


Figure 3.1. Position of arm with camera. a) optical axis of camera xtion1, b) camera xtion1, c) arm r1, d) arm r2.

3.3.2 Arm with Garment

Garment is held by gripper mounted on arm `r2`. Arm `r2` have two basic positions:

- **Position for Measurement** — The arm `r2` is in a position and ready for execution experiment. The arm `r2` holds garment in the gripper. The arm `r2` is in a height at which camera `xtion1` can capture movement of garment. The arm `r2` is in a position which it can perform movement required for the experiment (chap. ?? a chap ??).
- **Position for Reference Image** — This position is used for record a reference image of background, for improve results of the experiment. The record is used for filtering background from RGB image. The reference image of background is captured that the arm `r2` (in which gripper is held garment) change position so that the arm `r2` was completely out of recorded area of `xtion1`. In this position is performed the record of background and the arm `r2` with the garment was returned to the position of measurement. More to filtering out background will deal in chapter ??.

[subsec:refRGB]

3.3.3 External axis

`Ext.` axis (axis 13) is rotated so that in the background of captured garment is as least as possible disturbing objects. The best is single color flat surface.

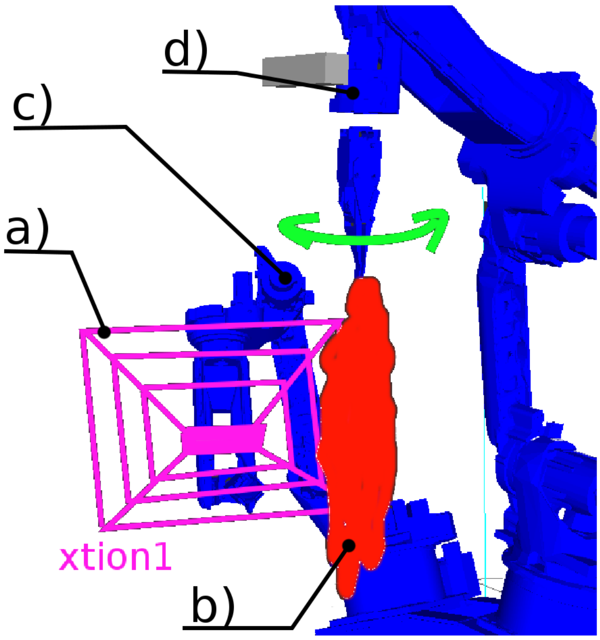
3.4 Arms movement

3.4.1 Movement of the arm so as garment moved perpendicularly to the optical axis

The arm `r1` does not perform any movement and is in the position described in the chapter ??. In gripper of arm `r2` is held garment. The arm `r2` makes a desired movement with this garment so that it rotates about an axis `B` certain angle and will return back to initial position. For better describe of the movement is movement mooted in the figure 3.2. This movement is suitable for capturing with RGB camera.

3.4.2 Movement of the arm so as garment moved along to the optical axis

The arm `r1` does not perform any movement and is in the position described in the chapter ??. In gripper of arm `r2` is held garment. The arm `r2` makes a desired movement with this garment so that it rotates about an axis `R` certain angle and will return back to initial position. For better describe of the movement is movement mooted in the figure 3.3. This movement is suitable for capturing with rangefinder.



[fig:kolmoOptOsy]

Figure 3.2. Suggestion of movements of gripper with garment perpendicular to optical axis. a) mooted of field of vision of camera xtion1, b) garment, c) arm r1, d) arm r2.

[fig:rovnoOptOsy]

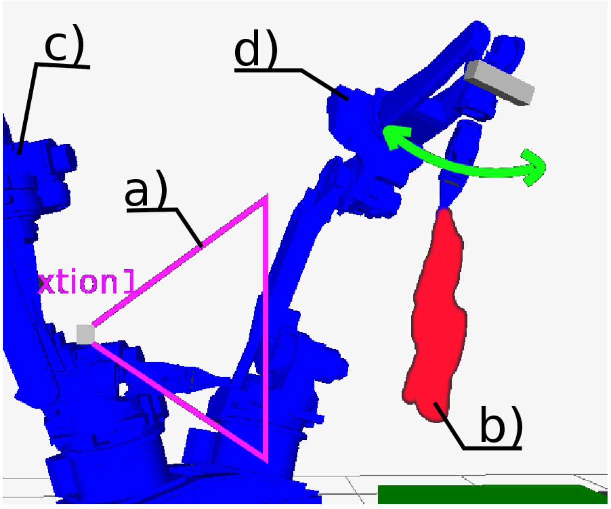


Figure 3.3. Suggestion of movements of gripper with garment along to optical axis. a) mooted of field of vision of camera xtion1, b) garment, c) arm r1, d) arm r2.

Chapter 4
Data Structure

For the purpose of the experiment is good data processed offline. It is therefore important to store the measured data to data structure and then in MATLAB calculate the parameters that are important for the experiment (chap. 5). If the results of experiment are good and quick, will be the calculation in the future transformed from MATLAB to the ROS.

4.1 Format of Recorded Data

Data is stored by using rosbag tool (chap. 2.2.1) in the format `.bag` to the folder set in the `local_options.py` file [1]).

[sec:topics]
4.2 Topics

The CloPeMa robot can produce over two hundred topics (chap. 2.2.1) when running. Due to the saving disk space and capacity of the transmission channel are recorded only topics which are important to the evaluation of the exporiment. Selected topics are set in `topics.txt` [2]) and contains these choosen topics:

```
/joint_states
/tf
/xtion1/depth/camera_info
/xtion1/depth_registered/camera_info
/xtion1/projector/camera_info
/xtion1/rgb/camera_info
/xtion1/depth/image_raw
/xtion1/rgb/image_raw
/xtion1/depth/disparity
```

Současný stav - předělat - došlo/dojde ke změně témat

4.3 Measured Data Set of the Garments

4.3.1 Structure of Data Set

Zde bude popsána datová sada a kde bude uložena

4.3.2 Format of Names of Recorded Files

Recorded files are stored under different names accord to the form `name_speed_AX.bag` (table 4.1).

[1]) `path_to_workspace/clopema_cvut/clopema_collect_model_data/src/local_options.py`
[2]) `path_to_workspace/clopema_cvut/clopema_collect_model_data/matlab/topics/topics.txt`

name	choosen file name by user
speed	choosen speed of manipulator
A	axis, which was executed movement **R** or **B** (figure 2.3)
X	number of topics file

[explanation]

Table 4.1. Explanation of format file name.

4.3.3 Description of the Garments

Zde bude výčet některých použitých látek jako hmotnosti, rozměry ...

[chap:dataproc]

Chapter 5 Data Processing

- U všech obrázku níže udělat alternativu (lépe dvě) a tu vložit do přílohy a odkázat na ní

5.1 Load Data to the MATLAB

- Popis + použitý kód

5.2 Extraction of Features from RGB

- Pohovořit v kostce, co očekávám, že dostanu z těchto dat a stručně, jak budu postupovat.
- Obrázek syrových dat 4 pcs

5.2.1 Rectification of RGB

- Popsat, jak opravím RGB snímek + obrázek

5.2.2 Filtering Background by Use Reference Image

- Způsob filtrace proti pozadí - napsat vzorec
- Popsat i použité morphologické operace pro zkvalitnění siluety (možná vlastní secc)
- Obrázek siluety 4 pcs

5.2.3 Finding End of Gripper

- Popsat, jak naleznu oblast, kterou opisuje chapadlo při hýbání s látkou a jak z tohoto pohybu naleznu konec chapadlo v obraze
- Obrázek s vyznačenou kružnicí a bodem jako koncem gripperu

5.2.4 Finding Central Curve of Garment

- Napsat, jak hledám osu bramboroidu
- Popsat zde zavrhnuté metody
  - Kostra grafu + obrázky + proč jsem to nepoužil
  - Střed dle y osy + obrázek + proč jsem to nepoužil
- Obrázky postupného nalezení osy bramborouidu (při aproximaci udělat více obrázků)

5.2.5 Finding Mathematical Features from RGB

- Popsat, jak z osy bramboroidu naleznu body, které předávám jako výstup
- Obrázky se siluetou a v ní s body

5.3 Extraction of Features from Depth Map

- Pohovořit v kostce, co očekávám, že dostanu z těchto dat a stručně, jak budu postupovat.
- Obrázky surových dat - depthmap

5.3.1 Rectification of Depth Map to 3D points

- Popsat způsob, napsat vzorec
- obrázky předělaného depthmap do 3D points

5.3.2 Filtering by Depth of Area

- Jak filtruji dle vzdálenosti pouze tak, aby mi zůstala hýbající se látka
- Obrázek filtrovaný dle hloubky

5.3.3 Finding Points

- Nalezení gripperu
- Vytvoření pole bodů s osou procházející gripperem
- Nápady:
    - snímat body v poly rozvnoměrně
    - snímat body ve sloupci dle osy
    - snímat celé tlusté řádky
- Přiřadit obrázky

5.3.4 Finding Mathematical Features from Depth Map

- Nalezení a vyplivnutí bodů ke zpracování

Chapter 6
Results

- V této kapitole VYMYSLET a provést statistiku typu: 5x jsem naměřil po sobě stejným způsobem stejnou látku (provést u více látek) a srovnat, zdali jsou si výsledky podobné na nějaké hladině významnosti.
- Naměřit více různých látek a zjistit, zda-li jsou si látky podobné (neměli by být) na nějaké hladině významnosti.
- Případně tuto statistiku vložit do příloh a sepsat zde jen výsledky a rozebrat je.
- Provést pro RGB i DepthMap data
- Vyrobit a vložit grafy

Chapter 7
Discussion

- Diskutovat použitelnost
- Napsat, co by se dalo zlepšit, případně i jak
- Podařilo se mi:
- Vyšlo mi:
- Funguje to tak a tak:
- Je to tak a tak rychlé:
- Je to tak a tak přesné:
- Tady jsou typické případy, kde to zafungovalo:
- Tady jsou typické případy, kdy to selhalo:
- Nejvíce si cením:
- Uvést nápady, které jsem nestihl realizovat jako možné pokračování
- Případné vynechání této kapitoly a diskutování v závěru

Chapter 8
Conclusion

- V práci je: ...
- Hlavní úspěchy jsou: ...
- Důležitými výsledky jsou: ...
- Podařilo se: ...
- Za nejdůležitější výsledek považuji:
- Možnost vynechání kapitoly DISCUSSION a uvedení jejího obsahu sem
- Pohled do budoucna (přeformulovat, změnit, rozšířit):
  - V případě, že se ukáže tento způsob sběru dat a tvorba modelu (odkaz na jinou bc.práci) užitečnou, bylo by dobré naprogramovat celý tento postup i s tvorbou modelu v operačním systému ROS, aby nebylo třeba dalších výpočetních nástrojů (MATLAB).
- Rekapitulovat naplnění všech bodů práce

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Appendix A
Specification

Appendix B
Content of included DVD

- Databaze látek
- Získané výsledky z nich
- Natočená videa
  - Videa z processingu - různé stupně a různé látky
  - Video z pracoviště - sběr dat
- Tato práce
- Všechny scripty
- (Manuál na sběr dat CZ)
- ReadMe

Appendix C
List of shortcuts

CTU	Czech Technical University in Prague.
KESF	The Kawabata Evaluation System for Fabric is used to measure the mechanical properties of fabrics.
FAMOUS	Fabric Automatic Measurement and Optimisation Universal System.
FAST	Fabric Assurance by Simple Testing.
OS	Operating System.
P2P	A Peer-To-Peer it's type of decentralized network.
PLMS	Pucker Laser Measurement System.
RGB	The aditive color model of using Red, Green and Blue colors of lights to create or capture the required color.
ROS	The Robot Operating System - an open source system is used for cotrol robots.
URI	Uniform Resource Identifier.

Appendix D
Brief Manual to Get Data Manually

- Přeložit návod z CZ do EN