Bachelor's thesis

Czech
Technical
University
in Prague

F3

Faculty of Electrical Engineering
Department of Cybernetics

Extraction of features from moving garment

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CYBERNETICS AND ROBOTICS, Robotics

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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.

Contents

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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). For these manipulations is very good to have some simplified dynamic physical model of real garment. 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 Art

The main sphere of using dynamic simulation of garment is computer graphic. These simulations are only for a realistic look, but not for real dynamic physical behavior of garment (including modern metod of simulating like [2]). Simulation of garment from real physical parameters deals e.g. [3]. **Dopsat pár vět + alespoň dva články**.

In the science and industry exist several measuring techniques which is used to find elementary parameters of fabrics e.g. KESF, FAST, PLMS or FAMOUS. 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). [4–7].

While existing methods give excellent results and a very detailed description of substances, but do not tell us anything about the whole garment. Moreover, these methods are very slow and very expensive.

We therefore propose which parameters we will need for build a simple dynamic physical model and we propose easiest way these parameters is obtained. 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 by the robot and we follow this movement by avaible 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

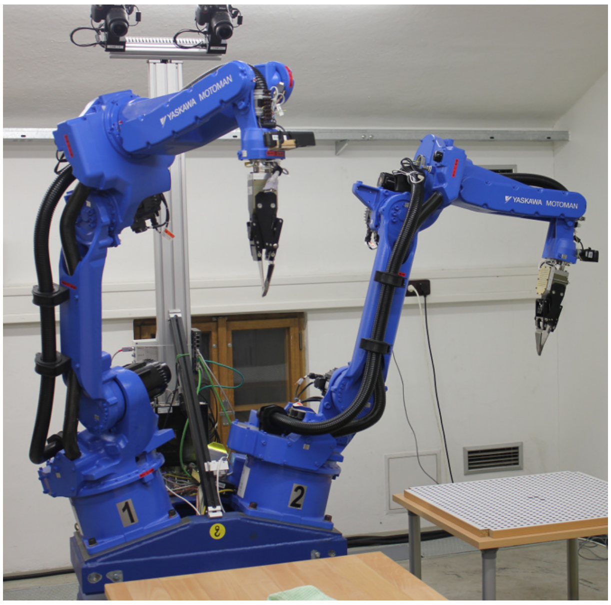
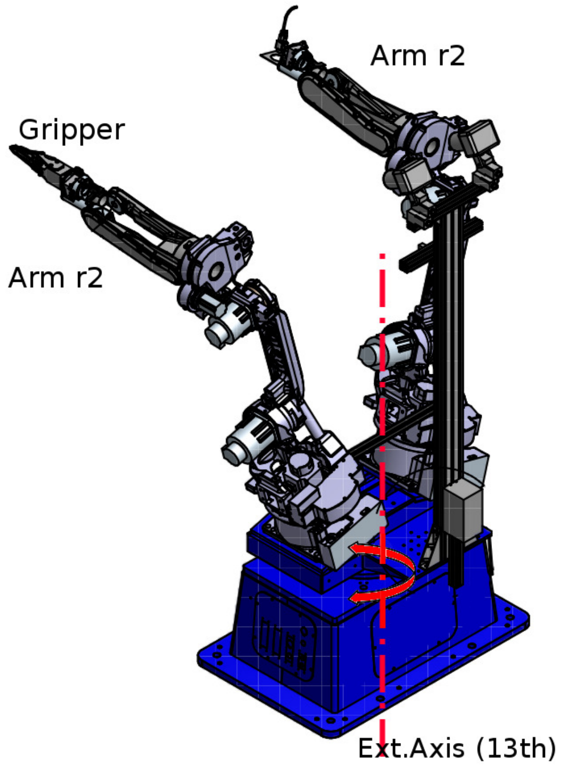


Figure 2.1. Manipulator of CloPeMa project location at CTU

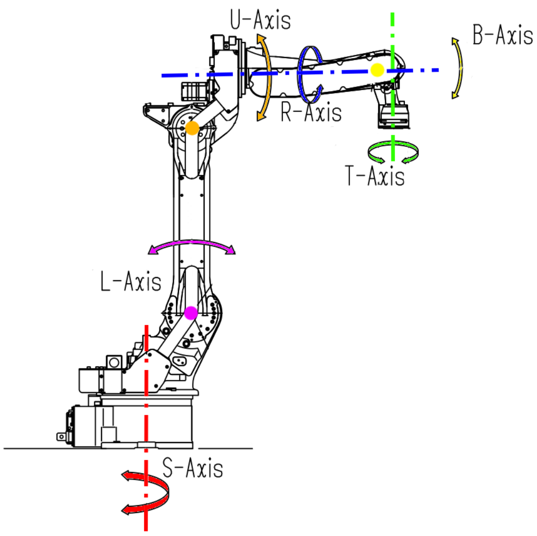
2.1.1 Manipulator

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). Each arm of manipulator has 6 axes, which is able to rotate. The axes are labeled according to the manufacturer with the letters `S`, `L`, `U`, `R`, `T` and `B` (figure 2.3). This designation is not enough to for recognize them and name of letters was assigned the number of the on which this axis are located. Eg.: `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.

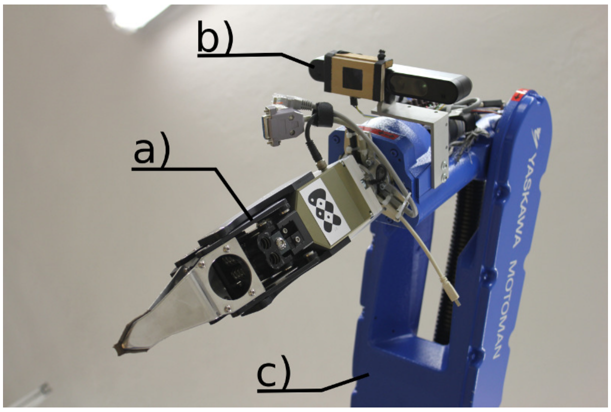


[fig:motomanAxis]

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 used to grasp of garment.



[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

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 [8]. In CloPeMa project is used Ubuntu as a host operating system. **Psát i hardware? Zmínit více i použití UBUNTU?**

[secc:rosintro]
2.2.1 Brief Introduction to the 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 [8].

Although the topic-based publish-subscribe model is a flexible communications paradigm, its "roadcast" 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 [8]. **Je podstatný tento odstavec? Nikde o službách nehovořím.**

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 [9]. With help of this tool we can record choosen topics, including timestamp, to the `*.bag` file.

Chapter 3
Way of getting data

[sec:requirements]
3.1 Requirements of experiment

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**. 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).

3.3 Positions of Manipulator

[fig:OptOsa]

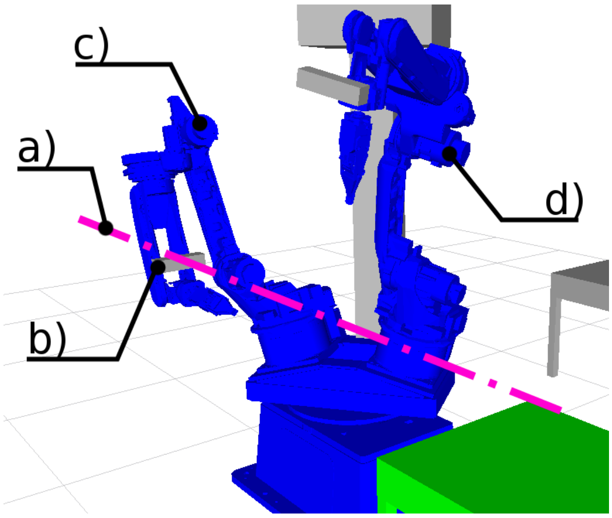


Figure 3.1. Position of arm with camera. a) optical axis of camera xtion1, b) camera xtion1, c) arm r1, d) arm r2.

3.3.1 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).

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.

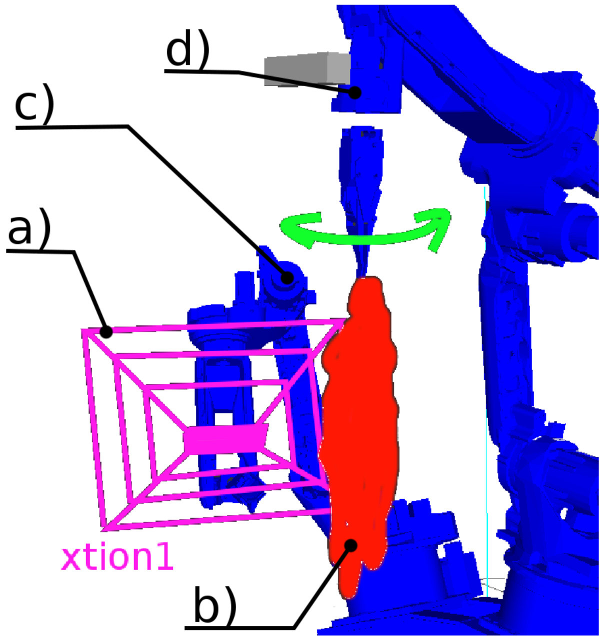
3.4 Arms movement

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.

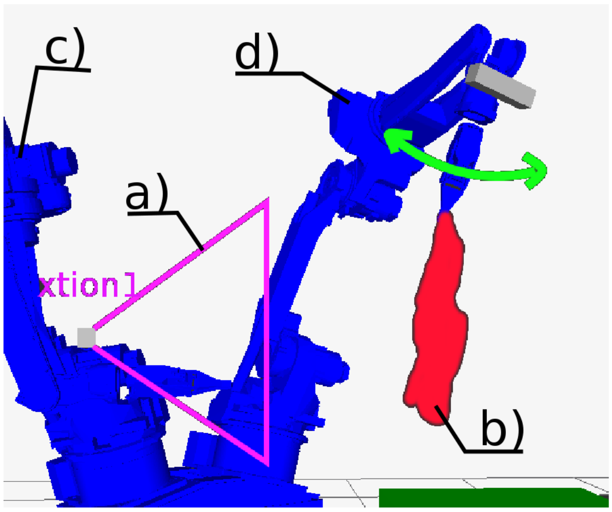
3.4.2 Movement of the arm so as garment moved along to the optical axis

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 experiment. 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

5.1 Load Data to the MATLAB

5.2 Processing of RGB Camera Data for Use silhouettes

5.2.1 Filtering Background by Use Reference Image

5.2.2 Finding Central Curve of Garment

5.2.3 Finding Mathematical Features

5.3 Processing of Rangefinder Data

5.3.1 Filtering by Depth of Area

5.3.2 Finding Points

5.3.3 Finding Mathematical Features

Chapter 6
Results

Chapter 7
Discussion

Chapter 8
Conclusion

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Appendix A
Specification

Appendix B
Content of included DVD

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.
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

Appendix E
Brief Manual for Using in Own Code