Karlsruher Institut für Technologie

Intelligente Prozess-automation und Robotik

Erstellung einer Methode zur Kostenkalkulation für sensorbasierte Sortieranlagen in verschiedenen Bereichen des Recyclings

Bachelorarbeit

von

Jan Niklas Ludwig

An der KIT-Fakultät für Informatik
Institut für Anthropomatik und Robotik (IAR) -
Intelligente Prozessautomation und Robotik (IPR)

Erstgutachter:	Prof. Dr.-Ing. Thomas Längle
Zweitgutachter:	Prof. Dr.-Ing.
Erster betreuender Mitarbeiter:	M.Sc. Merle Flitter
Zweiter betreuender Mitarbeiter:	M.Sc. Georg Maier

01. Dezember 2020 – 01. Main 2021

Institut für Anthropomatik und Robotik (IAR) -
Intelligente Prozessautomation und Robotik (IPR)
KIT-Fakultät für Informatik
Karlsruher Institut für Technologie
Engler-Bunte-Ring 8
76131 Karlsruhe

Jan Niklas Ludwig
Luise-Riegger-Straße 54
76137 Karlsruhe
uoxxa@student.kit.edu

Liste der noch zu erledigenden Punkte

Ich versichere wahrheitsgemäß, die Arbeit selbstständig angefertigt, alle benutzten Hilfsmittel vollständig und genau angegeben und alles kenntlich gemacht zu haben, was aus Arbeiten anderer unverändert oder mit Abänderungen entnommen wurde.

Karlsruhe, 21. Dezember 2020

. . . . . .

(**Jan Niklas Ludwig**)

Add Acknowledgments if you like!

Inhaltsverzeichnis

1. Einleitung

See the section 6.

1.1. Problemstellung

1.2. Ziel der Arbeit

1.3. Lösungskonzept

2. Stand der Wissenschaft und Technik

2.1. Schüttgut im Recycling

2.2. Sensorbasierte Sortierung

3. Kostenfaktoren der sensorbasierten Sortierung

See the section 6.

3.1. Aufteilung der Kosten einer sensorbasierten Sortiermaschine

3.1.1. Fixkosten

3.1.2. Variable Kosten

3.2. Einfluss der Vorkonditionierung

4. Versuche

See the section 6.

4.1. Statistische Versuchsplanung

4.2. Planung der Versuche

4.3. Versuchsdurchführung

4.4. Auswertung der Versuche

5. Erstellung eines Kostenmodells

See the section 6.

Literaturverzeichnis

[1] M. Deininger. *Studien-Arbeiten: ein Leitfaden zur Vorbereitung, Durchführung und Betreuung von Studien-, Diplom- und Doktorarbeiten am Beispiel Informatik*. vdf, 2005. ISBN 9783728130129. URL https://books.google.de/books?id=9vmtUu-812kC.

[2] Alexander Feil, Erdogan Coskun, Marcel Bosling, Sebastian Kaufeld, and Thomas Pretz. Improvement of the recycling of plastics in lightweight packaging treatment plants by a process control concept. *Waste Management and Research*, 37(2):120–126, 2019. ISSN 10963669. doi: 10.1177/0734242X19826372.

[3] Tobias Fuchs and M Sc Merle Flitter. Konstruktionstechnische Analyse , Weiterentwicklung und Validierung einer Pneumatischen Ausschleuseinheit zur automatischen Sortierung heterogener Materialströme Declaration / Erkl ¨ arung. 2020.

[4] Torsten Kroger and Friedrich M. Wahl. Multi-sensor integration and sensor fusion in industrial manipulation: Hybrid switched control, trajectory generation, and software development. In *2008 IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems*, pages 411–418, Aug 2008. doi: 10.1109/MFI.2008.4648030.

[5] Bert Leyendecker. *Statistische Versuchsplanung*, volume 158. 2016. ISBN 9783662557426. doi: 10.3139/9783446439924.022.

[6] Tad McGeer. Passive Dynamic Walking. *The International Journal of Robotics Research*, 9(2):62–82, 1990. doi: 10.1177/027836499000900206. URL http://ijr.sagepub.com/content/9/2/62.abstract.

[7] Matthias Porten and Jakob Feltes. Anschaffung von Sortieranlagen. *Das Deutsche Weinmagazin*, 2014.

[8] Natalie Rudolph. *Einführung Kunststoffrecycling*. Carl Hanser Verlag München, 2020. ISBN 9783446458802.

Anhang

A. First Appendix Section

Abbildung A.1.: A figure

...

Abbildungsverzeichnis

Tabellenverzeichnis

Listings

List of Algorithms

BibTex Eintrag für dieser Arbeit

```
@mastersthesis{Jan Niklas Ludwig_01. Main 2021,
  author = {Jan Niklas Ludwig},
  editor = {M.Sc. Merle Flitter, M.Sc. Georg Maier},
  ipr-thesis = Bachelorarbeit,
  keywords = {Keywords, of, my, Thesis, Keywords, of, my, Thesis, Keywords, of, my, Thesis, Keywords, of, my, Thesis, Keywords, of, my, Thesis, Keywords, of, my, Thesis},
  location = {Karlsruhe, Germany},
  month = ,
  pages = ,
  school = {Karlsruhe Institute of Technology},
  title = {Erstellung einer Methode zur Kostenkalkulation für sensorbasierte Sortieranlagen in verschiedenen Bereichen des Recyclings},
  year = {01. Main 2021}
}
```

6. How to use this Template

IMPORTANT: This chapter will disappear when you add final parameter on the document. See section 6.15.

6.1. Getting Started

Initially you **should only edit** the `My_document_info.tex` with important data regarding your work.

Add **content** in files in `Content` folder.

Add **bibliography** in the file `Bibliography/my_thesis_bibliography.bib` or just add a file from your supervisior in the `Bibliography` folder and reference it in the `\mybibliographyfiles` command in the `My_document_info.tex` file.

As an useful aid in all scientific work following book is recommended: [1].

6.2. Inline lists

My robot can: (i) forward and backward movements, (ii) sidewards movements, (iii) rotation along any curve in space, (iv) place of artificial forces along paths.

(1) the independently controllable wheels; (2) the rechargeable battery pack; (3) the Sick LMS100 laser range scanner; (4) the force-torque sensor; (5) the handlebar for controlling the robotic device

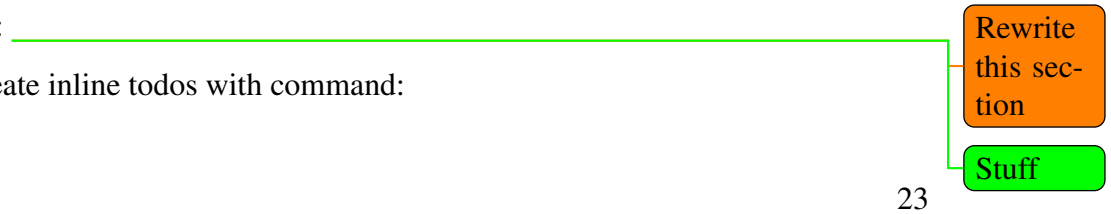
`https://ctan.math.illinois.edu/macros/latex/contrib/enumitem/enumitem.pdf`

6.3. Todos

Todo command can be used in multiple form and paramters set. You can set todos on the right side with commands:

```
\todo{Rewrite this section}
\todo[color=green]{Stuff}
```

which render as:



You can also create inline todos with command:

```
\todo[inline]{Rewrite this section}
\todo[inline,color=green]{Rewrite this section}
\todoin{Stuff}
```

which rendrs as:

Rewrite this section

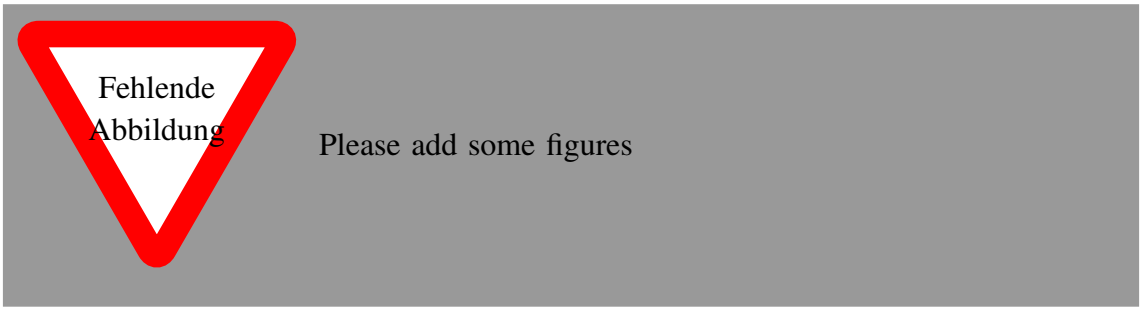
Rewrite this section

Stuff

One can also use command for figure placeholder with command:

```
\missingfigure{Please add some figures}
```

which renders as:



6.3.1. User defined version of ToDos for easier usage

Short for inline

```
\todoin{This I have to do}
```

This I have to do

Remember to rewrite something better

```
\todoBetter{This I have to do}
```

This I have to do

```
\todoBetterin{This I have to do}
```

This I have to do

Remember to add some stuff later

```
\todoAdd{This I have to do}
```

This I have to do

```
\todoAddin{This I have to do}
```

This I have to do

Remember to remove some copy-pasted text

```
\todoCopied{This I have to do}
```

```
\todoCopiedin{This I have to do}
```

This is copied and needs to be reworded: This I have to do

This is copied and needs to be reworded:

This I have to do

Remember that something is important to consider in the future

```
\todoImportant{This I have to do}
```

```
\todoImportantin{This I have to do}
```

IMPORTANT: This I have to do

IMPORTANT This I have to do

Remember that something need to be checked

```
\todoCheckThis{This I have to do}
```

```
\todoCheckThisin{This I have to do}
```

CHECK THIS: This I have to do

CHECK THIS: This I have to do

6.4. Glossaries and Acronyms

Please use `glossaries` package for this. See *documentation*.

Example (Acronym):

```
\newacronym{ipr}{IAR-IPR}{Institute for Anthropomatics and Robotics - Intellig
```

is used by

```
\gls{ipr}
```

rendering as “Institute for Anthropomatics and Robotics - Intelligent Process Control and Robotics (IAR-IPR)”, on the first use and as “IAR-IPR” on every following use. For further feature see *documentation*.

Please keep in mind that one has to call *external commands* for glossaries to work.

6.5. Nomenclature

For more details see *example*.

Use following command: \nomenclature{IAR-IPR}{Institute for Anthropomatics and Robotics (IAR) - Intelligent Process Control and Robotics (IPR)}

6.6. SI Units

Please use `siunitx` package for this. See: `https://ctan.org/pkg/siunitx`

6.7. Tables

Tabelle .1.: Tables have caption on top.

Object	Speed $[cm/s]$	Inner LR $[cm]$	Inner UR $[cm]$
Pitcher	real	n/a	5.65
	4.60	3.71 ± 0.67	5.09 ± 2.23
	10.64	3.55 ± 0.57	6.14 ± 0.69
Cookie O	real	7.55	7.55
	4.60	6.98 ± 0.27	6.98 ± 0.27
	10.64	6.77 ± 0.26	6.77 ± 0.26

Use `\longtable` for tables over multiple pages. See documentation.

6.8. Figures

Abbildung .1.: Figures have caption under. If you use figures from other work, do not forget to reference them [1].

6.9. Subfigures

(a) First logo **(b)** Second logo **(c)** Third logo

Abbildung .2.: Pictures of Logos

6.10. Citation

Add citet und citep

6.10.1. Multiple citations

Use multiple citation like this:

```
\cite{deininger2005studien, deininger2005studien}
```

rendered as “[1, 1]”.

6.10.2. More powerfull cite commands: `\citet` and `\citep`

For comprehensive description please check *the natbib documentation*.

Rather than using the awkward construction[1]

```
\cite{deininger2005studien} describes...
```

rendered as “[1] demonstrated...,” or the inconvenient [8]

[1] The example is from the template for the conference *Robotic Science and Systems*.

```
Deininger \cite{deininger2005studien} describes...
```

rendered as “Deininger [1] demonstrated...”, one can write

```
\citet{deininger2005studien} describes...
```

which renders as “Deininger [1] demonstrated...” and is both easy to write and much easier to read.

Citing specific chapter:

Kroger and Wahl [4, sec. III]

[4, sec. III]

For more examples check *the natbib documentation*.

6.11. Using Hyperlinks

Please use the ability of PDF viewers to interpret hyperlinks[2], specifically to allow each reference in the bibliography to be a link to an online version of the reference. As an example, if you were to cite “Passive Dynamic Walking” [6], the entry in the bibtex would read:

```
@article{McGeer01041990,
  author = {McGeer, Tad},
  title = {\href{http://ijr.sagepub.com/content/9/2/62.abstract}{Passive Dynamic Walking}},
  volume = {9},
  number = {2},
  pages = {62-82},
  year = {1990},
  doi = {10.1177/027836499000900206},
  URL = {http://ijr.sagepub.com/content/9/2/62.abstract},
  eprint = {http://ijr.sagepub.com/content/9/2/62.full.pdf+html},
  journal = {The International Journal of Robotics Research}
}
```

and the entry in the compiled PDF would look like:

[1] Tad McGeer. Passive Dynamic Walking. *The International Journal of Robotics Research*, 9(2):62–82, 1990.

where the title of the article is a link that takes you to the article on IJRR’s website.

Also use this for adding links into text as done in the [2]. For more information see documentation on wikibooks. The `hyperref` package is already configured for this document in `KIT_document_setup.tex` file.

6.12. Equations

Use numbered equations:

$$m \cdot \ddot{x}(t) + d \cdot \dot{x}(t) = F(t) \tag{6.1}$$

[2]The example is from the template for the conference *Robotic Science and Systems*.

6.13. Inline comments

Use command `\comment{}` for inline comments.

6.14. After Review marking

Use command `\afterReview{}` for marking text parts as changed.

6.15. Finalizing the Document

Please check here: `https://github.com/KITrobotics/Latex_Template/blob/master/README.md#finalizing-document`