

# Investigation of multispectral imaging algorithm for temperature determination on a numerical experiment platform in Laser-based Powder Bed fusion of Metals

Untersuchung des multispektralen Bildgebungsverfahrens zur Temperaturbestimmung auf einer numerischen Experimentierplattform beim Laser-basierten Pulverbett-Schmelzverfahren von Metallen.

Scientific work for obtaining the academic degree

**Master of Science (M.Sc.)**

at the Department of Mechanical Engineering of the Technical University of Munich

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<b>Submitted on</b>	July 31, 2023 in Garching



# Scope of Work

## **Title of the Semester Thesis:**

Investigation of multispectral imaging algorithm for temperature determination on a numerical experiment platform in Laser-based Powder Bed fusion of Metals

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**Issuance:** 15.03.2023

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**Submission:** 31.12.2021

## **Setting:**

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## **Objective:**

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## **Methodology:**

The content of the present thesis can be subdivided into the following tasks

- Method 1
- Method 2
- Method 3
- etc.



# Declaration

I hereby confirm that this master's/ bachelor's/ semester thesis was written independently by myself without the use of any sources beyond those cited, and all passages and ideas taken from other sources are cited accordingly.

.....  
Location, Date

.....  
Signature

With the supervision of Mr. Max Mustermann by Mr. Mein Betreuer intellectual property of the Professorship Laser-based Additive Manufacturing (LBAM) flows into this work. A publication of the work or a passing on to third parties requires the permission of the head of the professorship. I agree to the archiving of the printed thesis in the LBAM library (which is only accessible to LBAM staff) and in LBAM's digital thesis database as a PDF document.

.....  
Location, Date

.....  
Signature

## Abstract

Here could be your abstract. so where should i start with?[1]. haha[2]

## Zusammenfassung

Hier könnte Ihre Kurzzusammenfassung stehen.

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# 1 LaTeX-Tutorial

Dieses Tutorial liefert eine Kurzeinführung[1] in die Verwendung von Latex.

## 1.1 Titelseite

Die Titelseite wird in `./main.tex` definiert. Der Studienarbeitstyp wird durch Ein- und Auskommentieren der Befehle

- `\IWBstudentthesisTitlePageCustomMastersThesis,`
- `\IWBstudentthesisTitlePageCustomBachelorsThesis` und
- `\IWBstudentthesisTitlePageCustomSemesterThesis`

ausgewählt und die Seite entsprechend der Argumente gesetzt. Die Professoren und Lehrstühle können mittels der Makros

- `\IWBnamesProfReinhart \newline \IWBlangChairMWIWBLBM` oder
- `\IWBnamesProfZaeh \newline \IWBlangChairMWIWBLWF`

ausgewählt werden.

## 1.2 Zitation

Zum Zitieren stehen die Standardbefehle `\textcite` und `\parencite` zur Verfügung. Soll der Autorenname im Satz verwendet werden, eignet sich ersteres, z.B. Bayerlein, Bodensteiner, Zeller, Hofmann, and Zaeh [3, pp. 2–3] bezieht sich auf Bayerlein, Zeller, Wunderer, Weirather, Schmid, Seidel, Zaeh, Hessert, Schlick, Uihlein, and Hofmann [4]. Soll das Zitat in Klammern nach die Aussage gestellt werden empfiehlt sich zweiteres [5]. Sammelzitationen am Satzende schreiben sich wie folgt [1], [6], [7]. Die Zitation von Online-Quellen kann schwierig sein, da nicht immer der Autor und das Erscheinungsjahr verfügbar sind. Vergleicht man Heuss and Roder [8] und *iwb-Startseite* [9], stellt man fest, dass bei zweiteren der Seitentitel statt des bekannten Schemas eingesetzt wird.

Normen werden als *DIN ISO EN 10218-2* [10] dargestellt. Im Bibtex-Export des verwendeten Literaturverwaltungsprogramm sind bestimmte Einstellungen vorzunehmen. Dokumententyp ist “@book” mit folgenden Einträgen:

- Normtyp und Nummer als “title”
- Langtitel als “subtitle”
- Verlag als “publisher”
- Jahr als “date”
- “author” darf nicht belegt werden!

### 1.3 Abkürzungen

In `./source/abbreviations.tex` können Abkürzungen definiert werden. Es gibt Besonderheiten zu Ausdrücken, deren Pluralendung nicht auf `s` endet. Hier müssen ggf. Kurz- und Langformen des Ausdrucks auch für den Plural definiert werden.

- `\gls{ros}`: schreibt beim ersten Auftreten im Dokument ausführlich Robot Operating System (ROS), ab dem zweiten Auftreten wird abgekürzt ROS
- `\glspl{ap}` verwendet den Plural in Langform Arbeitspakete (APs) und danach in Kurzform APs

### 1.4 Glossar

In `./source/glossary.tex` können Begriffe erklärt, abgegrenzt oder definiert werden. Begriffe erhalten einen Namen und eine Beschreibung als Glossareintrag sowie ein Label zum Referenzieren im Text. Ein Glossar ist Optional.

- `\gls{latex}`: Schreibt den Namen aus dem Glossarverzeichnis mit Verweis auf den Glossareintrag `Latex`

### 1.5 Abbildungen

Graphiken und Bilder können in beliebigen Dateiformaten eingebunden werden, vergleiche fig. 1. Vektorgraphiken sind im Allgemeinen Pixelgraphiken in Schärfe und Speicherbedarf überlegen.

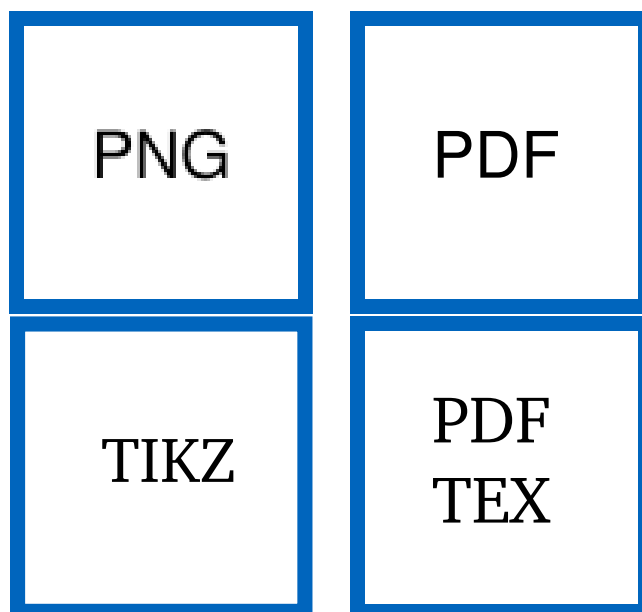


Figure 1: Beschreibung des Bilds. Außerdem machen wir nun die Bildunterschrift unnötig lang um die Formatierung zu testen.

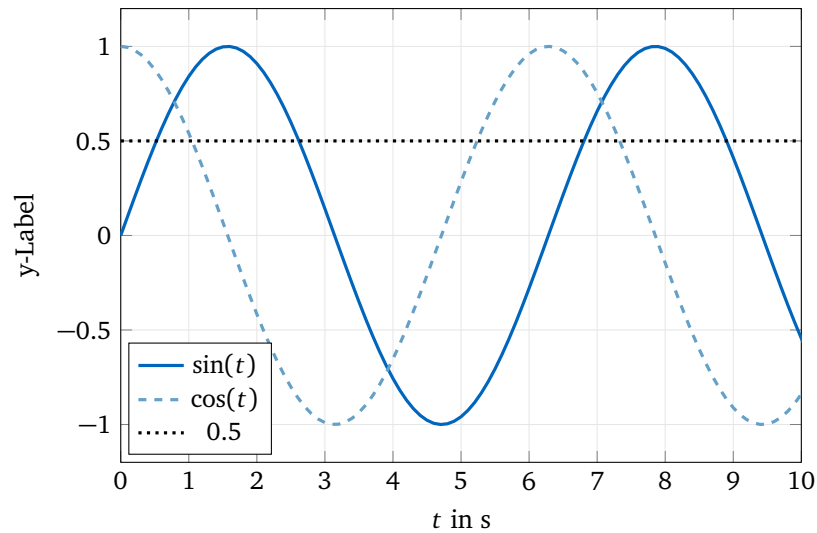


Figure 2: Beschreibung des Plots. Außerdem machen wir nun die Bildunterschrift unnötig lang um die Formatierung zu testen.

Für Nutzer mit perfektionistischen Anspruch empfiehlt sich die Nutzung von TikZ. Vorteil ist, dass die Erzeugung von Daten und die Darstellung komplett getrennt werden. Die Darstellung erfolgt einheitlich gemäß eines generischen Mark-Ups, vergleiche figs. 2 and 3.



Figure 3: Beschreibung des Plots. Außerdem machen wir nun die Bildunterschrift unnötig lang um die Formatierung zu testen.



## 2 Introduction

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

### 2.1 Section Introduction

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

#### 2.1.1 Subsection Introduction

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

### 2.2 Another Section Introduction

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

### 2.3 Many Section Introductions

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there

no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

## 2.4 Many More Section Introductions

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Another lorem ipsum to test formatting.

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. And one more for good measure.

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Rinse and repeat.

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest

gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

## 2.5 Testing the Continuous Figure Numbering

Here we have a graph which should have a continuous caption numbering i. e. it should say Figure 4 or Figure 5, instead of Figure 2.1 or Figure 2.2.

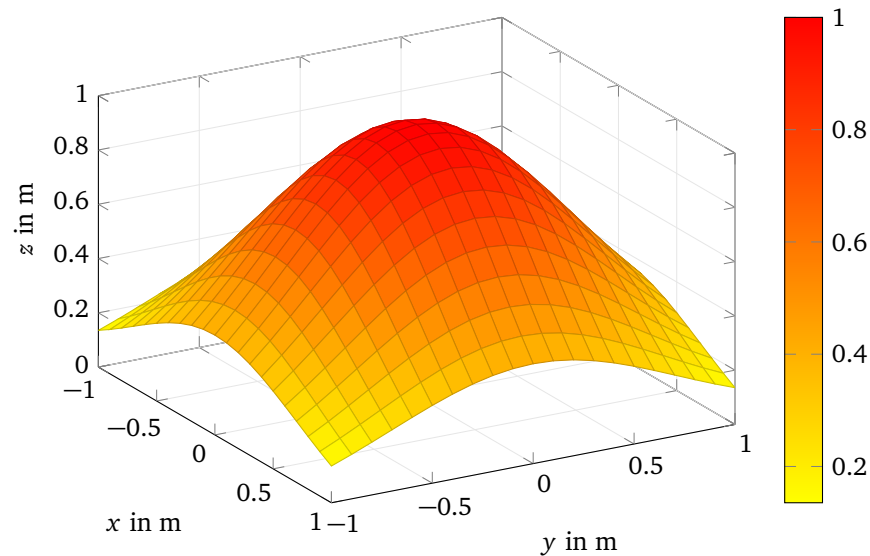


Figure 4: Beschreibung des Plots. Außerdem machen wir nun die Bildunterschrift unnötig lang um die Formatierung zu testen.

## 2.6 Now Let's test tables

The table 1 should have captions above the table instead of captions below, like Figures.

Table 1: This table caption should be above the table. Otherwise DIN is going to judge you...

Col1	Col2	Col2	Col3
1	6	87837	787
2	7	78	5415
3	545	778	7507
4	545	18744	7560
5	88	788	6344





## 3 Kapitelname

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

### 3.1 Abschnittname

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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#### 3.2.2 Unterabschnittname

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# A Anhangname

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

After this fourth paragraph, we start a new paragraph sequence. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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# Glossary

Latex	Generische Mark-up-Sprache zum Erstellen wissenschaftlicher Texte. Sie ist in jeder Hinsicht Word überlegen, welches einem visuellen Mark-Up entspricht. Das X von $\text{\LaTeX}$ wird als ç (Stimmloser palataler Frikativ) ausgesprochen, vergleiche deutsche Aussprache von <i>ch</i> .
TikZ	Frontend-Paket, das auf PGF-Plot aufbaut und zum Erstellen von Graphiken dient.
Tutorial	Kurze Gebrauchsanleitung welche ein Thema, einen gewissen Vorgang oder eine Funktion erklärt. Hat nicht den Anspruch auf Vollständigkeit.





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# List of Abbreviations

AP	Arbeitspaket
LBAM	Professorship Laser-based Additive Manufacturing
ROS	Robot Operating System



# Disclaimer

I hereby declare that this thesis is entirely the result of my own work except where otherwise indicated. I have only used the resources given in the list of references.

Garching, July 31, 2023

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(Signature)