DHBW
Duale Hochschule
Baden-Württemberg

Evaluation von Typst zur Erstellung einer Abschlussarbeit

Studienarbeit

Course of Studies Informatik

Duale Hochschule Baden-Württemberg Karlsruhe

Jeremie Bents

Marvin Lindner

Submitted on:	30.01.2025
Student ID, Course:	1941564, TINF22B2 4274538, TINF22B2
Company:	SAP SE, 69190, Walldorf SAP SE, 69190, Walldorf
Supervisor in the Company:	
Supervisor at DHBW:	Dr. Roland Schätzle

Contents

1

Introduction

1.1 Motivation

The primary motivation behind this study is to develop a robust software system capable of automatically detecting smiling and laughing faces. The project is inspired by the popular series “Last One Laughing” (LOL), where the ability to monitor and analyze facial expressions in real-time can significantly enhance the viewing experience. This study aims to leverage advanced facial recognition and emotion detection technologies to create a service that can accurately identify and respond to facial expressions. The literature review will cover existing methods and technologies in facial recognition and emotion detection, highlighting the advancements and challenges in the field. The scope of this study includes the development, implementation, and evaluation of the proposed system.

1.2 Problem

The current state of facial recognition and emotion detection technologies presents several challenges and limitations. While there have been significant advancements, existing systems often struggle with accuracy and real-time performance, especially in dynamic environments. The primary problem addressed in this study is the need for a reliable and efficient system that can detect smiling and laughing faces in real-time with high accuracy. The gap identified is the lack of a specialized solution tailored for the specific requirements of the LOL series, including real-time monitoring, immediate response, and high reliability. This study aims to bridge this gap by developing a system that meets these specific needs.

1.3 Research Framework and Objectives

The importance of this research lies in its potential to enhance the viewing experience of the LOL series by providing a reliable and efficient facial expression detection system. The research problem is to develop a system that can accurately detect smiling and laughing faces in real-time. The research aims and objectives include:

- Developing a facial recognition module to detect faces in camera streams.
- Implementing an emotion detection module to identify smiling and laughing expressions.
- Ensuring real-time performance and immediate response to detected expressions.
- Evaluating the system's accuracy and reliability through comprehensive testing.

The hypotheses of this study are:

1. The proposed system will accurately detect smiling and laughing faces in real-time.
2. The system will provide immediate responses to detected expressions with minimal latency.

The methodology includes the development of the system using Python, leveraging existing libraries and frameworks for facial recognition and emotion detection. The study will also involve extensive testing and evaluation to ensure the system meets the defined requirements.

1.4 Thesis Structure

The order of information in this thesis will follow a structured approach:

1. Introduction: Provides the motivation, problem statement, and research objectives.
2. Literature Review: Reviews existing methods and technologies in facial recognition and emotion detection.
3. Methodology: Details the development process, tools, and techniques used.
4. Implementation: Describes the implementation of the facial recognition and emotion detection modules.
5. Testing and Evaluation: Presents the testing procedures, results, and evaluation of the system's performance.
6. Conclusion: Summarizes the findings, discusses the implications, and suggests future work.

This structure ensures a logical flow of information, guiding the reader through the research process and findings.

2

Fundamentals

- Fundamentals of Facial Recognition and Emotion Detection
- Psychological Theories and Mechanisms of Smiling and Laughter
- Overview of Machine Learning and Deep Learning Techniques in Visual Analysis

TODO

Marvin: planned structure:

- Theoretically we need to explain what human emotions are (emphasize on smiling)
- Machine Learning
- Neural Networks
  - Convolutional Neural Networks
    - Feature Based
    - Image Based

Image Processing

- Technologies

further topics that need to be covered:

- Haar Feature

2.1 History of Facial Recognition

Facial recognition technology started in the 1960s, when early computer programs could analyze facial features by measuring the distances between key points, such as the eyes and nose. A major milestone came in the 1990s with the introduction of the "eigenfaces" approach, which used mathematical algorithms to identify unique facial

characteristics automatically. This made facial recognition significantly more accurate and practical, opening doors for its use in security and surveillance. By the early 2000s, it was implemented in airports and other high-security areas, particularly for public safety.

Today, facial recognition has become a common feature worldwide. In countries like China, it's used extensively in public spaces for surveillance, shopping, and even as a payment method. In the United States, law enforcement agencies use it to identify suspects, while smartphones like iPhones and many Android devices offer face unlock features for secure access. Many airports globally also use facial recognition to streamline passport control.

Public reactions to facial recognition are mixed. On the one hand, people appreciate its convenience for personal use and the added layer of security it provides in certain settings. However, there are significant privacy concerns. In the European Union, strict data privacy laws have slowed down its adoption for surveillance, and in the United States, several cities and states have passed legislation limiting its use. Many worry about data security, the potential for mass surveillance, and possible biases that could lead to misidentification. This ongoing debate has led to calls for more regulation to ensure that facial recognition technology is used responsibly and ethically.

[1], [2], [3]

2.2 Emotion Recognition

The automotive industry is using FER to enhance driver safety and comfort. Emotion recognition systems in vehicles can detect a driver's mood and alertness, adjusting safety mechanisms accordingly.
But also Companies use emotion detection tools to analyze consumer sentiments about products. For example, virtual try-on apps can benefit from emotion recognition by capturing the user's response to different makeup looks or hairstyles. This feedback can help brands recommend products that customers are likely to enjoy and purchase.

For market research, emotion detection tools can be used for real-time analysis of viewer reactions to ads, allowing advertisers to optimize content for emotional engagement and tailor advertising to the viewer's emotional state [4].

2.3 Machine Learning

Machine Learning (ML) is a subfield of Artificial Intelligence (AI) focused on enabling computers to learn from data and make predictions without explicit programming. The term "machine learning" was coined by Arthur Samuel in the 1950s, who developed algorithms that allowed computers to improve performance through experience.

Neural networks, a key component of ML, are computational models inspired by the human brain. They consist of layers of interconnected neurons that process and learn from data. Early breakthroughs, including backpropagation, by researchers like Geoffrey Hinton and Yann LeCun, allowed neural networks to effectively handle tasks like pattern recognition.

Today, ML is widely applied across various fields, including supervised learning for tasks like medical diagnosis and unsupervised learning for clustering and recommendation systems. It is also central to advancements in natural language processing, image and speech recognition, and autonomous systems such as self-driving cars. The continued growth of data and computational power drives the increasing integration of ML into modern technologies. [5]

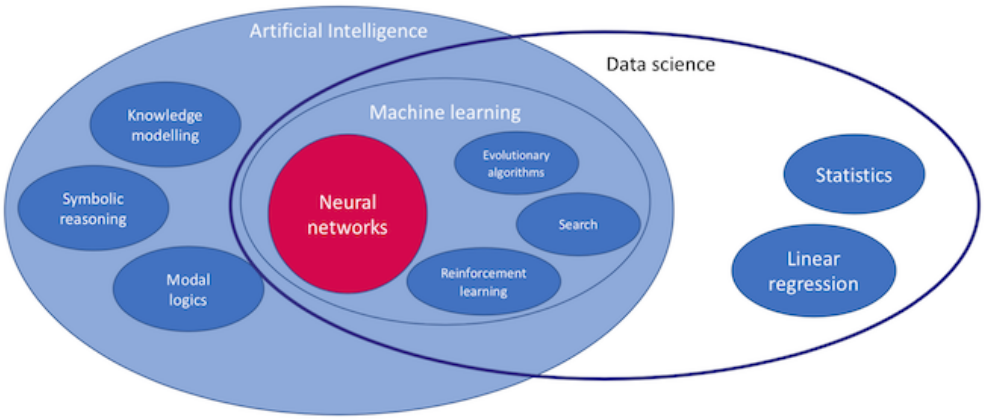

Figure 1 — Machine Learning Field

This image was found in [6].

2.4 Neural Networks

A Neural Network (NN) is a general framework of interconnected nodes, or "neurons," organized in layers. Typically, it consists of an input layer, one or more hidden layers,

and an output layer. In standard neural networks, each neuron in one layer connects to every neuron in the next, creating what is called a “fully connected” structure. This setup is suitable for tasks like classification, regression, and prediction. However, it is less efficient when handling large image data, as it does not inherently recognize spatial patterns, such as edges or textures, within images.

That is for a Convolutional Nerual Network (CNN). It is a specialized type of neural network designed to process image and video data effectively. CNNs use convolutional layers to apply filters to small sections of the image, allowing the network to extract features like edges, shapes, and textures. This convolutional process preserves the spatial relationships within the image, making CNNs exceptionally effective for tasks like image recognition and classification.

The unique structure of CNNs often includes:
- Convolutional Layers that extract essential features from the image,
- Pooling Layers that reduce data volume while emphasizing significant features, and
- Fully Connected Layers that integrate these features and produce the final classification.

This architecture makes CNNs more efficient than standard neural networks by reducing the number of parameters and focusing on image-specific patterns, allowing CNNs to process visual data with a high degree of accuracy.

[7], [8]

3

Methodology

- Data Collection and Preprocessing Techniques (e.g., dataset selection, annotation strategies, data sanitization)
- Selection of Model Architecture and Algorithms (e.g., Convolutional Neural Networks, Recurrent Neural Networks)
- Model Training Protocols and Performance Metrics for Evaluation

Review of Current Research and Technologies

- Systematic Overview of Contemporary Methods for Facial Expression Recognition
- Comparative Analysis of Existing Emotion Recognition Systems
- Identification of Gaps, Challenges, and Limitations in Current Technologies

3.1 Wie hilf Tensorflow uns bei der Entwicklung

3.2 Wozu dient OpenCV

4

Implementation of the Model

5

Implementation of the Website

6

Experimental Setup and Results

- Design of Experiments and Test Environment
- Quantitative Evaluation of System Accuracy (e.g., accuracy, precision, recall, F1 score)
- Comprehensive Analysis and Interpretation of Experimental Findings

7

Conclusion

A References

[1] Thales, “Was ist ein Convolutional Neural Network?.” Accessed: Nov. 14, 2024. [Online]. Available: https://www.thalesgroup.com/en/markets/digital-identity-and-security/government/inspired/where-facial-recognition-used

[2] N. Braun Binder, E. Kunz, and L. Obrecht, “Maschinelle Gesichsterkennung im öffentlichen Raum.” Accessed: Nov. 14, 2024. [Online]. Available: https://edoc.unibas.ch/88208/

[3] R. Campillo, “Facial Recognition History.” Accessed: Nov. 14, 2024. [Online]. Available: https://www.mobbeel.com/en/blog/facial-recognition-history/#:~:text=The%20initial%20steps%20in%20facial,RAND%20tablets%20in%20the%201960s.

[4] D. Mekinec, “Facial Recognition History.” Accessed: Nov. 14, 2024. [Online]. Available: https://visagetechnologies.com/facial-emotion-recognition-guide/

[5] S. J. Bigelow, “Machine learning vs. neural networks: What`s the difference?.” Accessed: Nov. 14, 2024. [Online]. Available: https://www.techtarget.com/searchenterpriseai/answer/Machine-learning-vs-neural-networks-Whats-the-difference

[6] S. Van Otterloo, “AI, Machine Learning and neural networks explained.” Accessed: Nov. 14, 2024. [Online]. Available: https://ictinstitute.nl/ai-machine-learning-and-neural-networks-explained/

[7] The MathWorks Inc., “What is a neural network?.” Accessed: Nov. 14, 2024. [Online]. Available: https://de.mathworks.com/discovery/convolutional-neural-network.html#:~:text=Ein%20Convolutional%20Neural%20Network%20(CNN,Klassen%20und%20Kategorien%20zu%20erkennen.

[8] IBM, “Was ist ein Convolutional Neural Network?.” Accessed: Nov. 14, 2024. [Online]. Available: https://www.ibm.com/topics/neural-networks

B Acronyms

AI	Artificial Intelligence
API	Application Programming Interface
CNN	Convolutional Nerual Network
HTTP	Hypertext Transfer Protocol
ML	Machine Learning
NN	Neural Network
REST	Representational State Transfer

C Glossary

Komponente	Ein Architekturbaustein. Zusammengesetzte Komponenten bestehen aus weiteren Subkomponenten. Einfache Komponenten sind nicht weiter unterteilt.
Softwareschnittstelle	Ein logischer Berührungspunkt in einem Softwaresystem: Sie ermöglicht und regelt den Austausch von Kommandos und Daten zwischen verschiedenen Prozessen und Komponenten.

Confidentiality Statement

The Thesis on hand

Evaluation von Typst zur Erstellung einer Abschlussarbeit

contains internal respective confidential data of SAP SE. It is intended solely for inspection by the assigned examiner, the head of the Informatik department and, if necessary, the Audit Committee at the Duale Hochschule Baden-Württemberg Karlsruhe.

The content of this thesis may not be made available, either in its entirety or in excerpts, to persons outside of the examination process and the evaluation process, unless otherwise authorized by the training institution (SAP SE).

Walldorf 30.01.2025

Jeremie Bents

Marvin Lindner

Declaration of Authorship

Gemäß Ziffer 1.1.13 der Anlage 1 zu §§ 3, 4 und 5 der Studien- und Prüfungsordnung für die Bachelorstudiengänge im Studienbereich Technik der Dualen Hochschule Baden-Württemberg vom 29.09.2017. Wir versichern hiermit, dass wir unsere Arbeit mit dem Thema:

Evaluation von Typst zur Erstellung einer Abschlussarbeit

selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt haben. Wir versichern zudem, dass alle eingereichten Fassungen übereinstimmen.

Walldorf 30.01.2025

Jeremie Bents

Marvin Lindner