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Automated Image Quality Assessment in Tele dermatology

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Code / Thesis Classification:

- ☒ Public (Standard)
☐ Private

Declaration

I hereby declare that I have completed this thesis alone and without any unauthorized or external help. I further declare that all the sources, references, literature and any other associated resources have been correctly and appropriately cited and referenced. The confidentiality of the project provider (industry partner) as well as the intellectual property rights of the Lucerne University of Applied Sciences and Arts have been fully and entirely respected in completion of this thesis.

Rotkreuz, Sunday 21st April, 2024

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Expression of Thanks and Gratitude

Expression of thanks and gratitude here...

Abstract

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Chapter 1

Introduction

Problem, Fragestellung, Vision

Welche Ziele, Fragestellungen werden mit dem Projekt verfolgt? Die Bedeutung, Auswirkung und Relevanz dieses Projektes für die unterschiedlichen Beteiligten soll aufgeführt werden. Typischerweise wird hier ein Verweis auf die Aufgabenstellung im Anhang gemacht.

introduce importance of automated IQA, particularly in teledermatology

highlight recent advancements in AI and its applicaiton in image analysis, including role of deep learning

identify challenges associated with manual image quality asessment in TD and the impact of poor image quality on diagnosis accuracy

1.1 Background and Problem Statement

In recent years, the way we seek dermatological advice has changed significantly, mainly due to the COVID-19 pandemic. Teledermatology, a branch of telemedicine, has gained traction as a means to remotely diagnose and manage skin conditions. This approach relies heavily on mobile applications, allowing patients to snap pictures of their skin issues using everyday devices like smartphones and tablets. These images are then sent to dermatologists for assessment, eliminating the need for in-person appointments.

However, the success of teledermatology depends heavily on the quality of the images patients capture. Despite the convenience of modern technology, factors like poor lighting, blurry pictures, and unclear depiction of skin problems can make it difficult for dermatologists to give accurate diagnoses. As a result, they face challenges in interpreting these subpar images, which hampers their ability to provide accurate remote diagnoses.

Furthermore, it's important to note that many images submitted by patients don't meet the required standards. This widespread issue highlights the urgent need to improve the clarity and accuracy of images captured through mobile applications.

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identify challenges associated with manual image quality assessment in TD and the impact of poor image quality on diagnosis accuracy

1.2 Objectives of the Thesis

The primary aim of this thesis is to develop and assess automated methods for evaluating image quality in the context of teledermatology. Specific goals include conducting a comprehensive literature review on image quality assessment (IQA) methods in the general image domain and exploring their applicability to teledermatology. Furthermore, the objectives encompass selecting appropriate quality assessment metrics, evaluating these methods using relevant dermatology datasets, and establishing a reproducible repository.

In detail, the objectives are as follows:

- **Literature Review:** Conduct an extensive review of state-of-the-art image quality assessment methods, focusing on their applicability to teledermatology. This review will serve as the foundation for developing robust quality assessment techniques tailored to dermatological images.
- **Identification of Image Quality Criteria:** Identify and delineate specific image quality criteria relevant to the accurate diagnosis of skin conditions in teledermatology. This step is crucial for establishing benchmarks and guidelines for assessing image quality in dermatological contexts.
- **Evaluation of Methods:** Evaluate selected quality assessment methods on publicly available dermatology datasets. This evaluation process will involve assessing the efficacy and accuracy of these methods in objectively quantifying image quality.
- **Development of a Reproducible Repository:** Create a well-documented and reproducible repository that facilitates the replication of reported results and enables the assessment of image quality for new patient images. This repository will serve as a valuable resource for researchers and practitioners in the field of teledermatology.

Achieving these objectives is expected to enhance the efficiency and accuracy of teledermatology by establishing a standardized process for assessing image quality. This, in turn, will streamline the workflow in teledermatology, providing robust tools and methodologies for assessing the quality of patient images. Ultimately, these advancements will contribute to improved diagnostic accuracy and patient care in remote dermatological consultations.

1.3 Structure of the Thesis

text

Chapter 2

Literature Review

Stand der Forschung oder Stand der Praxis/Technik

Bezogen auf die eigenen Zielsetzungen und Fragestellungen soll aufgezeigt werden, wie andere dieses oder ähnliche Probleme gelöst haben. Worauf können Sie aufbauen, was müssen Sie neu angehen? Wodurch unterscheidet sich Ihre Lösung von anderen Lösungen? Für wissenschaftlich orientierte Arbeiten sei hier explizit auf (Balzert, S. 66 ff) verwiesen.

2.1 Image Quality Assessment (IQA)

text

2.1.1 Introduction to IQA

text

2.1.2 Metrics Used in IQA

text

2.1.3 Benchmark Datasets for IQA

text

2.1.4 State-of-the-Art in IQA

text

2.1.5 Quality Criteria for Image Assessment

text

2.1.6 Challenges and Opportunities in IQA

text

2.1.7 Previous Research in IQA

text

2.2 Teledermatology

The following section provides an overview of teledermatology, a specialized field of dermatology that utilizes telecommunications technology to provide remote diagnosis and consultation for skin conditions. This section discusses the importance of image quality in teledermatology, quality criteria for teledermatology images, as well as challenges and opportunities associated with the practice.

2.2.1 Introduction to Teledermatology

The term "teledermatology" combines "tele", which refers to distance or remote communication, and "dermatology", the medical field focused on skin health. This specialized branch of dermatology utilizes telecommunications technology to provide remote diagnosis and consultation for skin conditions.

This innovative approach to healthcare delivery is particularly beneficial for patients in remote or underserved areas, as well as for those with mobility issues. Teledermatology services can be provided in real-time, or through store and forward images, wherein the patient captures images of their skin or any skin-related issues using a camera or smartphone and send them electronically to a dermatologist, along with relevant details about their condition, such as symptoms and medical history. This allows dermatologists to assess the skin condition remotely and provide recommendations or treatment plans without the need for an in-person visit.

2.2.2 Importance of Image Quality in Teledermatology

High-quality images are essential for accurate diagnosis in teledermatology. While poor image quality can lead to misinterpretation of skin lesions, incorrect diagnosis or missed diagnosis.

With good image quality the dermatologists can better assess the severity of skin conditions and formulate appropriate treatment plans.

No in-person visits and improve accessibility to specialized care.

Maintaining consistent image quality standards ensures the reliability and reproducibility of teledermatology services. It minimizes variability and enhances the overall reliability of remote diagnosis and consultation process

show good and bad quality images!!

2.2.3 Quality Criteria for Teledermatology Images

The table is temporary and will be replaced as subsubsections with more detailed information and images later on.

| Criteria | Description |
|--------------------------------------|--|
| Lighting | <ul style="list-style-type: none"> - make sure skin color/tone are accurately captured. - AVOID using flash or light: could whiten skin tone, reduce contrast and cause reflection. - USE natural light: best for regional and close up, but impractical in clinical settings. <p>position light source at an angle to skin (not directly overhead or perpendicular)</p> |
| Background Color | <ul style="list-style-type: none"> - reflection from object in background can change appearance of skin color. <p>solid background color and contrast between background and skin</p> |
| Field of View for Dermoscopic Images | <ul style="list-style-type: none"> - enough distance from skin to include entire lesion. - multiple images help ensure all edges of lesion are visualized and recorded <p>center lesion of area of interest</p> |
| Image Orientation | <ul style="list-style-type: none"> - consistency is important to compare area of interest over time. - cephalic, vertical, horizontal orientation |
| Focus and Depth of Field | <ul style="list-style-type: none"> - camera perpendicular to skin and lens with deep depth of field <p>center of lesion or area of interest should be used as focus point</p> |
| Resolution | <ul style="list-style-type: none"> - defines how much detail to capture and result in larger file size - hair follicles should be sharp in regional images - skin markings should be sharp visible in close up images <p>JPEG and at least 200KB in size</p> |
| Scale and Measurement | <ul style="list-style-type: none"> - report lesion size and changes in dimension over time - avoid problem of skewed rulers <p>digital scale incorporated into devices and software</p> |
| Color Calibration | <ul style="list-style-type: none"> - should be comparable over time and regularly calibrated. |
| Image Storage | <ul style="list-style-type: none"> - store for regulatory and clinical reasons <p>JPEG, TIFF, EXIF, DICOM</p> |

2.2.4 Challenges and Opportunities in Teledermatology

Challenges: picture taken by the patient is not in a good quality, patient data security and privacy, including compliance with regulations. The whole patient cannot be examined, only localised. No touching of skin. Demands diligence in documentation, storage and consent. Who has the clinical accountability or responsibility. Double charging. Teledermatology is not included in training curriculum for doctors. Different patient experience. Barriers in practice such as individual preference of doctors, resistance to change and no benefit in investing time to adapt.

Opportunities: increase access to care, reduce waiting times, reduce travel time and costs, increase patient satisfaction, increase efficiency, increase access to specialist care, increase access to education and training, increase access to research and clinical trials, increase access to data and analytics, increase access to technology and innovation, increase access to collaboration and networking, increase access to telemedicine and telehealth.

2.2.5 Previous Research in Teledermatology

The article by Primary Care Commissioning in 2011 outlined quality standards for teledermatology services using store and forward images. These standards include:

- Standard 1: Models of teledermatology services including links to other services
- Standard 2: Selecting patients for teledermatology
- Standard 3: Gaining the patient's informed consent
- Standard 4: Competent staff
- Standard 5: The teledermatology referral: patient history and suitable images
- Standard 6: Communication between referring and reporting clinician
- Standard 7: Information governance and record-keeping
- Standard 8: Audit and quality control

These standards serve as guidelines for ensuring the quality and effectiveness of teledermatology services, particularly in the context of using store and forward images.

Chapter 3

Methodology

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3.1 Literature Review Methodology

text

3.1.1 Overview of Different Review Techniques

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3.1.2 Selection of Systematic Literature Review Approach

text

3.1.3 Rationale for Chosen Methodology

text

3.2 Image Quality Assessment (IQA) Methodology

text

3.2.1 Criteria for Selecting IQA Methods

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3.3 Teledermatology Methodology

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3.3.1 Criteria for Selecting Teledermatology Methods

text

3.3.2 Selection of Benchmark Datasets for Teledermatology

text

3.3.3 Implementation Plan for Teledermatology Methods

text

Chapter 4

Implementation

text

Chapter 5

Results and Analysis

Realisierung

Dies ist das Hauptkapitel Ihrer Arbeit! Hier wird die Umsetzung der eigenen Ideen und Konzepte (Kapitel 3) anhand der gewählten Methoden (Kapitel 4) beschrieben, inkl. der dabei aufgetretenen Schwierigkeiten und Einschränkungen.

Evaluation und Validation

Auswertung und Interpretation der Ergebnisse. Nachweis, dass die Ziele erreicht wurden, oder warum welche nicht erreicht wurden.

Chapter 6

Discussion and Conclusion

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Appendix A

Code

Anhang, Abkürzungs-, Abbildungs-, Tabellen-, Formel-Verzeichnis, Literaturverzeichnis nicht vergessen!

Anhänge

Projektspezifisch können weitere Dokumentationsteile angefügt werden wie:
Aufgabenstellung, Projektmanagement-Plan/Bericht, Testplan/Testbericht,
Bedienungsanleitungen, Details zu Umfragen, detaillierte Anforderungslisten, Referenzen auf projektspezifische Daten in externen Entwicklungs- und Datenverwaltungstools etc.

Listing A.1: Caption on PDF

```
import numpy as np
```