Quantifying the Robustness of Image Segmentation Algorithms for Medical Assistance Systems

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Matr.-Nr.: 209437
September 13, 2023, Heilbronn

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1 Introduction

1.1 Background and Motivation

Image Segmentation, a pivotal technique in the medical domain, enables the detection of tissue abnormalities, such as tumors, and assists in segmenting medical imaging from X-Rays, CT scans, and MRIs(Kürbig & Sauter, 2005). Another application of image segmentation is to replace current tracking systems, that require additional hardware like magnetic field based trackingbianchi-2019 (Bianchi et al., 2019,p.2) or optical trackers (Koivukangas et al., 2013,p.2). While these applications are groundbreaking, the success of image segmentation hinges on two critical pillars - accuracy and robustness. Accurate segmentation ensures that the features of medical images are correctly identified, facilitating precise diagnosis. But in the medical field not only accuracy is important, but also the robustness of the predictions. For a physician to make informed decisions aided by an image segmentation algorithm, it needs to be reliable in a wide variety of different settings. Optimally, the algorithm rejects all images it can not make a reliable prediction on and it is additionally ensured, that the number of rejected images is as small as possible (Deserno, 2008). The concept of robustness in image segmentation, will be delved into in greater detail in subsequent chapters. To ensure that a given algorithm is fit to be used in the medical field, there is a need for an independent certification. Therefore, there has to be an objective way to quantify the robustness of image segmentation algorithms. This study seeks to find a transparent measure by developing a comprehensive testing framework able to evaluate them in different scenarios. Anyone releasing new image segmentation algorithms for the medical field could then use this framework to certify their product. This helps medical practitioners make informed decisions with an easy to read robustness scale and improves patient safety by ensuring only adequate software is used. Developers could benefit from the transparent robustness scale, because it shows their software meets standards for accuracy and robustness, which has long been the norm for medical devices, because it reduces the risk of recalls due to defects and potential lawsuits (The Importance of ISO 13485 Certification to Medical Device Manufacturing | Smithers, 05.08.2023.) The platform that is being developed quantifies robustness, has an open Interface to enable broad usage and can be extended to test the image segmentation with different types of interference effects. Because the process is automated, it helps to provide a cheap and easy way to test an image segmentation algorithm for its readiness to be deployed in the medical field.

Table 1: Übersicht der SUS Ergebnisse aus dem Screening der Enable Studie

Interference Effect	**Value Ranges**
Glare	2,38
Brightness[1]	2,38
Darkness	0,79
4	0
5[1]	3,97
6[1]	7,14
7	0
8	0
9	1,59
10	1,59

* Zur Auswertung werden die Antwortmöglichkeiten des SUS mit Zahlen kodiert. stimme gar nicht zu –> 1; stimme voll zu –> 5.

References

Kürbig, J., & Sauter, M. (2005). *Seminar: Bildsegmentierung und computer vision ws 2005/6.* Retrieved August 12, 2023, from https://www.mathematik.uni-ulm.de/stochastik/lehre/ws05_06/seminar/ausarbeitung_sauter.pdf#:~:text=Das%20Verfahren%20der%20Bildsegmentierung%20findet%20Anwendung%20in%20zahlreichen,auch%20zur%20Segmentierung%20von%20R%C3%B6ntgenbildern%20und%20der%20Computertomographie.