[1] Calisto, F.M., 2017. Medical Imaging Multimodality Breast Cancer Diagnosis User Interface. Master's Thesis. Instituto Superior Técnico, Avenida Rovisco Pais, 1. DOI: 10.13140/RG.2.2.15187.02084

Abstract

Breast cancer is one of the most commonly occurring types of cancer among women. The primary strategy to reduce mortality is early detection and treatment based on medical imaging technologies. The current workflow applied in breast cancer diagnosis involves several imaging multimodalities. The fact that no single modality has high enough sensitivity for a reliable diagnosis supports the need for multi-modal imaging in breast cancer diagnosis. Nevertheless, their combination can significantly increase diagnostic accuracy. It also reduces the number of unnecessary biopsies, leading to better patient care and lower healthcare costs. In this work, we used interaction techniques to build a user interface adapted to the standard needs of a radiology room. This user interface allows the combination of MG, US, MRI and Text Data to assist the clinician in establishing the diagnosis. The work involves the development and design of a user interface for automatic detection, segmentation and classification from breast MG, US and MRI, as well as, textual data notations and information visualisation. We conclude, through user analysis and evaluation, that our methods, techniques and developments are satisfactory. Moreover, this work provides a framework that can be applied to new medical interaction systems.

[2] Calisto, F.M., Ferreira, A., Nascimento, J.C. and Gonçalves, D., 2017, October. Towards Touch-based Medical Image Diagnosis Annotation. In Proceedings of the 2017 ACM International Conference on Interactive Surfaces and Spaces (pp. 390-395). DOI: 10.1145/3132272.3134111

Abstract

A fundamental step in medical diagnosis for patient follow-up relies on the ability of radiologists to perform a trusty diagnostic from acquired images. Basically, the diagnosis strongly depends on the visual inspection over the shape of the lesions. As datasets increase in size, such visual evaluation becomes harder. For this reason, it is crucial to introduce easy-to-use interfaces that help the radiologists to perform a reliable visual inspection and allow the efficient delineation of the lesions. We will explore the radiologist's receptivity to the current touch environment solution. The advantages of touch are threefold: (i) the time performance is superior regarding the traditional use, (ii) it has more intuitive control and, (iii) for less time, the user interface delivers more information per action, concerning annotations. From our studies, we conclude that the radiologists still exhibit a resistance to change from traditional to touch based interfaces in current clinical setups.

[3] Calisto, F.M. and Nascimento, J.C., Instituto Superior Tecnico, 2020. Computational Method and System for Improved Identification of Breast Lesions. U.S. Patent Application 18/029,407. Online: US20230360202A1

Abstract

The present invention falls within the field of medical imaging, specifically imaging aimed at identifying breast lesions, specifically, identifying potential breast cancer lesion masses or potential cancer lesion calcifications of the breast. The object of the present invention is a computational method for the improved identification of breast lesions that involves obtaining digital images of a breast section, with at least two digital images obtained by different imaging technologies, their segmentation and consequent correlations, to identify one or more cancer lesions. This allows for improved automation of the identification of breast lesions.

[4] Calisto, F.M., Nunes, N. and Nascimento, J.C., 2020, September. BreastScreening: On the Use of Multi-Modality in Medical Imaging Diagnosis. In Proceedings of the International Conference on Advanced Visual Interfaces (pp. 1-5). DOI: 10.1145/3399715.3399744

Abstract

This paper describes the field research, design and comparative deployment of a multimodal medical imaging user interface for breast screening. The main contributions described here are threefold: 1) The design of an advanced visual interface for multimodal diagnosis of breast cancer (BreastScreening); 2) Insights from the field comparison of Single-Modality vs Multi-Modality screening of breast cancer diagnosis with 31 clinicians and 566 images; and 3) The visualization of the two main types of breast lesions in the following image modalities: (i) MammoGraphy (MG) in both Craniocaudal (CC) and Mediolateral oblique (MLO) views; (ii) UltraSound (US); and (iii) Magnetic Resonance Imaging (MRI). We summarize our work with recommendations from the radiologists for guiding the future design of medical imaging interfaces.

[5] Calisto, F.M., Santiago, C., Nunes, N. and Nascimento, J.C., 2021. Introduction of Human-Centric AI Assistant to Aid Radiologists for Multimodal Breast Image Classification. International Journal of Human-Computer Studies, 150, p.102607. DOI: 10.1016/j.ijhcs.2021.102607

Abstract

In this research, we take an HCI perspective on the opportunities provided by AI techniques in medical imaging, focusing on workflow efficiency and quality, preventing errors and variability of diagnosis in Breast Cancer. Starting from a holistic understanding of the clinical context, we developed BreastScreening to support Multimodality and integrate AI techniques (using a deep neural network to support automatic and reliable classification) in the medical diagnosis workflow. This was assessed by using a significant number of clinical settings and radiologists. Here we present: i) user study findings of 45 physicians comprising nine clinical institutions; ii) list of design recommendations for visualization to support breast screening radiomics; iii) evaluation results of a proof-of-concept BreastScreening prototype for two conditions Current (without AI assistant) and AI-Assisted; and iv) evidence from the impact of a Multimodality and

AI-Assisted strategy in diagnosing and severity classification of lesions. The above strategies will allow us to conclude about the behaviour of clinicians when an AI module is present in a diagnostic system. This behaviour will have a direct impact in the clinicians workflow that is thoroughly addressed herein. Our results show a high level of acceptance of AI techniques from radiologists and point to a significant reduction of cognitive workload and improvement in diagnosis execution.

[6] Calisto, F.M. and Santiago, C. and Nunes, N. and Nascimento, J.C., 2022. BreastScreening-AI: Evaluating Medical Intelligent Agents for Human-AI Interactions. Artificial Intelligence in Medicine, 127, p.102285. DOI: 10.1016/j.artmed.2022.102285

Abstract

In this paper, we developed BreastScreening-AI within two scenarios for the classification of multimodal beast images: (1) Clinician-Only; and (2) Clinician-AI. The novelty relies on the introduction of a deep learning method into a real clinical workflow for medical imaging diagnosis. We attempt to address three high-level goals in the two above scenarios. Concretely, how clinicians: i) accept and interact with these systems, revealing whether are explanations and functionalities required; ii) are receptive to the introduction of AI-assisted systems, by providing benefits from mitigating the clinical error; and iii) are affected by the AI assistance. We conduct an extensive evaluation embracing the following experimental stages: (a) patient selection with different severities, (b) qualitative and quantitative analysis for the chosen patients under the two different scenarios. We address the high-level goals through a real-world case study of 45 clinicians from nine institutions. We compare the diagnostic and observe the superiority of the Clinician-AI scenario, as we obtained a decrease of 27% for False-Positives and 4% for False-Negatives. Through an extensive experimental study, we conclude that the proposed design techniques positively impact the expectations and perceptive satisfaction of 91% clinicians, while decreasing the time-to-diagnose by 3 min per patient.

[7] Calisto, F.M. and Nunes, N. and Nascimento, J.C., 2022. Modeling Adoption of Intelligent Agents in Medical Imaging. International Journal of Human-Computer Studies, 168, p.102922. DOI: 10.1016/j.ijhcs.2022.102922

Abstract

Artificial intelligence has the potential to transform many application domains fundamentally. One notable example is clinical radiology. A growing number of decision-making support systems are available for lesion detection and segmentation, two fundamental steps to accomplish diagnosis and treatment planning. This paper proposes a model based on the unified theory of acceptance and use of technology to study the determinants for the adoption of intelligent agents across the medical imaging workflow. We tested the model via confirmatory factor analysis and structural equation modeling using clinicians' data from an international evaluation of healthcare practitioners. Results show an increased understanding of the vital role of security, risk, and trust in the usage intention of intelligent agents. These empirical findings

provide valuable theoretical contributions to researchers by explaining the reasons behind the adoption and usage of intelligent agents in the medical imaging workflow.

[8] Abrantes, J.M., et al. 2023. External Validation of a Deep Learning Model for Breast Density Classification. European Congress of Radiology. DOI: 10.26044/ecr2023/C-16014

Abstract

The present study involved a cross-sectional analysis of observational data of female patients without a personal history of breast cancer who underwent mammography in clinical practice between January and December 2021. The data was retrospectively collected and consisted of 3356 mammograms, representing the four standard views of the routine mammography of 839 patients. The reports of the mammography examinations were retrieved from the electronic medical record system, and the corresponding breast density assessments, as determined by the reporting radiologists using the BI-RADS classification system, were obtained and recorded.

[9] Morais, M., Calisto, F.M., Santiago, C., Aleluia, C. and Nascimento, J.C., 2023, April. Classification of Breast Cancer in MRI with Multimodal Fusion. In 2023 IEEE 20th International Symposium on Biomedical Imaging (ISBI) (pp. 1-4). IEEE. DOI: 10.1109/ISBI53787.2023.10230686

Abstract

Magnetic resonance imaging (MRI) is the recommended imaging modality in the diagnosis of breast cancer. However, each MRI scan comprises dozens of volumes for the radiologist to inspect, each providing its own set of information on the tissues being scanned. This paper proposes a multimodal framework that processes all the available MRI data in order to reach a diagnosis, instead of relying on a single volume, mimicking the radiologists' workflow. The framework comprises a 3D convolutional neural network for each modality, whose predictions are then combined using a late fusion strategy based on Dempster-Shafer theory. Results highlight the most relevant modalities required to obtain accurate diagnosis, in agreement with clinical practice. They also show that combining multiple modalities leads to better overall results than their individual counterparts.

[10] Diogo, P., Morais, M., Calisto, F.M., Santiago, C., Aleluia, C. and Nascimento, J.C., 2023, April. Weakly-Supervised Diagnosis and Detection of Breast Cancer Using Deep Multiple Instance Learning. In 2023 IEEE 20th International Symposium on Biomedical Imaging (ISBI) (pp. 1-4). IEEE. DOI: 10.1109/ISBI53787.2023.10230448

Abstract

The detection and classification of breast cancer lesions with computer-aided diagnosis systems has seen a huge boost in recent years due to deep learning. However, most works focus on 2D image modalities. Dealing with 3D MRI adds new challenges, such as data insufficiency and

lack of local annotations. To handle these issues, this work proposes a new two-stage framework based on deep multiple instance learning, which requires only global labels (weak supervision) and provides: 1) classification of the whole volume and of each slice; and 2) 3D localization of lesions through heatmaps. Results show that the proposed approach achieves performances that are competitive with the state of the art, and a qualitative assessment of the heatmaps illustrates the effectiveness of this approach in finding the malignant lesion in the images.

[11] Calisto, F.M., Nascimento, J.C., Santiago, C. and Nunes, N., Instituto Superior Tecnico, 2023. Machine Learning System for Diagnosing Breast Lesions, Adaptable to the Clinician and Based on Assertiveness. PT Patent Application PT118,618.

Abstract

The present disclosure is in the field of relates to the medical imaging field, specifically, imaging and associated computer systems for identifying breast lesions. The subject of the present disclosure is a machine learning system for diagnosing breast lesions (10), comprising a first database (11) a second database (12) and at least one server (20) interconnected with the first and second databases, that trains (110) and uses classifying classifier agents (140) to determine a classification and respective segmentation associated with breast lesions through the determination of probable physical parameters with the determination of a probability of occurrence, based on digital images of a breast section (120). The computational determination of probable physical parameters is adapted based on the demographic characteristics of the clinician (130), thus implementing a solution with varying degrees of assertiveness (150). This solution improves on known solutions by determining a degree of probability degree of the existence of breast lesions existence through a highly adaptable computer system trained for this purpose.

[12] Calisto, F.M., Fernandes, J., Morais, M., Santiago, C., Abrantes, J.M., Nunes, N. and Nascimento, J.C., 2023, April. Assertiveness-based Agent Communication for a Personalized Medicine on Medical Imaging Diagnosis. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (pp. 1-20). DOI: 10.1145/3544548.3580682

Abstract

Intelligent agents are showing increasing promise for clinical decision-making in a variety of healthcare settings. While a substantial body of work has contributed to the best strategies to convey these agents' decisions to clinicians, few have considered the impact of personalizing and customizing these communications on the clinicians' performance and receptiveness. This raises the question of how intelligent agents should adapt their tone in accordance with their target audience. We designed two approaches to communicate the decisions of an intelligent agent for breast cancer diagnosis with different tones: a suggestive (non-assertive) tone and an imposing (assertive) one. We used an intelligent agent to inform about: (1) number of detected findings; (2) cancer severity on each breast and per medical imaging modality; (3) visual scale

representing severity estimates; (4) the sensitivity and specificity of the agent; and (5) clinical arguments of the patient, such as pathological co-variables. Our results demonstrate that assertiveness plays an important role in how this communication is perceived and its benefits. We show that personalizing assertiveness according to the professional experience of each clinician can reduce medical errors and increase satisfaction, bringing a novel perspective to the design of adaptive communication between intelligent agents and clinicians.

[13] Calisto, F.M., 2024. Human-Centered Design of Personalized Intelligent Agents in Medical Imaging Diagnosis. PhD Thesis. Instituto Superior Técnico, Avenida Rovisco Pais, 1.

Abstract

As intelligent agents advance, they promise to enhance decision-making in high-stakes domains. This thesis focuses on designing and adapting these agents for specific audiences like radiology clinicians. It explores prerequisites for integrating anthropomorphic intelligent agents as second-reader diagnostic support, their role in clinical workflows, user acceptance dynamics, and the impact of personalized recommendations. The initial phase explores the adoption of intelligent agents by proposing a model rooted in the unified theory of acceptance and use of technology. This model examines factors influencing agents' adoption throughout the medical imaging workflow, emphasizing the role of security, risk, and trust. These findings provide insights into improving the integration of intelligent agents into healthcare settings. We then explore applying deep learning to medical imaging diagnostics, utilizing a human-centric design approach, focusing on breast cancer. The development and evaluation of the BreastScreening-AI framework, integrating multimodal imaging and AI for image analysis, demonstrate gains in diagnostic efficiency and reduced cognitive workload with improvements in clinicians' satisfaction. The thesis underscores the transformative power of intelligent agents in augmenting clinicians' workflows and decision-making. The dissertation concludes by exploring customized communication between intelligent agents and clinicians. We investigated the influence of two contrasting communication tones on clinicians' receptivity and performance: (1) suggestive (non-assertive); and (2) imposing (assertive). Findings reveal that assertiveness-based agents can reduce medical errors and enhance satisfaction, introducing a novel perspective on adaptive communication in assisted healthcare. Ultimately, this dissertation contributes to human-computer interaction by emphasizing clinicians' needs and the essentials of incorporating intelligent agents into healthcare. The execution of design interventions emphasizes the importance of a human-centered approach, focusing on clinicians' needs in developing novel, accessible solutions in critical domains. The thesis investigates clinicians' attitudes towards intelligent agents, providing insights to direct future healthcare design and research, marking it as a crucial field reference.