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AI-OPTIMUS: Artificial Intelligence-Supported Optical Precision Therapy and Integrated Management of Basal Cell Carcinoma

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Introduction

Basal cell carcinoma (BCC) is the most common skin cancer worldwide. Conventional diagnostic and therapeutic workflows require separate procedures, increasing treatment time and patient burden. AI-OPTIMUS aimed to develop an integrated system combining non-invasive optical diagnostics, targeted therapy, and artificial intelligence (AI). Optical coherence tomography (OCT) was integrated with a long-pulsed infrared laser to support automated BCC diagnosis, treatment planning, and therapy guidance, providing a basis for personalized, minimally invasive treatment.

Methods

The project comprised data preparation, AI development and system integration. A curated dataset of OCT images from 73 histologically confirmed BCC lesions of 36 participants and adjacent healthy skin was annotated, quality-controlled, and augmented. Deep learning learning models were trained to detect BCC subtype, tumor thickness, and spatial extent. The models were integrated into the OCT-laser platform for real-time image analysis and automated adjustment of treatment parameters.

Results

The best configuration used a multi-dataset pre-training with 981 images from a legacy dataset, random 2D slices from the Dresden in vivo dataset, and a retinal OCT dataset provided by Jiaxuan Li. A custom nnU-Net trainer loaded pretrained weights and froze all layers except the final segmentation layer for 10 epochs, using an initial learning rate of 0.01 and a factor of 0.1. Five-fold cross-validation and majority voting produced an overall Dice similarity coefficient (DSC) of 0.3807. Tissue-specific DSCs were 0.9323 for healthy skin, 0.1000 for infiltrative BCC, 0.1803 for superficial BCC (sBCC), and 0.3102 for nodular BCC. The algorithms identified characteristic BCC morphology, estimated clinically relevant tumor parameters, and enabled real-time therapy planning within a closed diagnostic-therapeutic workflow.

Conclusion

AI-OPTIMUS demonstrates the feasibility of integrating OCT, AI, and laser therapy for BCC diagnosis and treatment. This approach may streamline workflows, personalize therapy, and reduce invasiveness, while providing a technological basis for futre clinical studies and further development toward routine clinical application.

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