SVEUČILIŠTE U ZAGREBU
GRAFIČKI FAKULTET
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Postupak ocjene doktorskog rada

DOKTORAND/ICA:	Dinka Radonić, akad. snim.

NASLOV RADA na hrv. jeziku:	Sustav simultanoga zapisa multispektralne fotodokumentacije i stereoskopske videodokumentacije u vizualnom i blisko infracrvenom spektru
NASLOV RADA na engl. jeziku:	A System for the Simultaneous Recording of Multispectral Photodocumentation and Stereoscopic Videodocumentation in the Visual and Near-Infrared Spectrum

SAŽETAK:

Mul3spect je sustav za bilježenje multispektralnog i stereoskopskog sadržaja koji omogućuje spektralno i dimenzionalno proširenu reprodukciju stvarnosti. Sustav se sastoji od triju kamera postavljenih na zajedničku nosivu konstrukciju, pri čemu se interesno područje istodobno snima multispektralno u vidljivim i blisko infracrvenim pojasevima te u stereoskopskoj tehnici. Na taj se način isti prizor bilježi kroz više komplementarnih informacijskih slojeva, čime se fotografski i videozapis nadopunjuju podacima koji nisu dostupni uobičajenim metodama snimanja. Multispektralnim zapisom podataka omogućuje se proširen grafički prikaz materije. Takav pristup može omogućiti izdvajanje detalja koji u standardnom vizualnom prikazu nisu jasno uočljivi ili se dovoljno ne razlikuju od drugih struktura u promatranom području. Stereoskopska komponenta sustava dodatno proširuje dokumentacijski potencijal jer omogućuje doživljaj dubine i prostornosti koji nije ostvariv u dvodimenzionalnom videozapisu. Time se korisniku omogućuje jasnija percepcija prostornih odnosa i struktura unutar snimljenog prizora. Definirani su procesi izrade multispektralnog fotografskog zapisa i stereoskopskog videozapisa, te mogućnosti njihove obrade i reprodukcije. Na taj se način omogućuje pregled materijala na zahtjev te usporedba istog prizora kroz različite spektralne i prostorne prikaze. U radu se ispituje primjena dizajniranog sustava u operacijskoj sali te se predstavlja inovativni model dokumentacije kirurških postupaka. Sustav je zamišljen kao alat za stvaranje dopunskog multimedijskog edukativnog materijala koji omogućuje naknadni pregled operacijskog tijeka iz optimalne promatračke pozicije. Mul3spect se stoga može promatrati kao eksperimentalni sustav koji povezuje multispektralno i stereoskopsko snimanje u svrhu zapisa vizualno i prostorno proširene dokumentacije materije.
Ključne riječi: multispektralno snimanje, stereoskopsko snimanje, fotodokumentacija, videodokumentacija

EXTENDED ABSTRACT:

Photography and videography have increasingly become vital tools in modern scientific research, serving as supplementary or even primary methods for data collection and analysis. This doctoral thesis introduces Mul3spect, an innovative system enabling simultaneous multispectral and stereoscopic recording, offering a more comprehensive representation of reality through the integration of spectral and spatial dimensions. The Mul3spect system consists of three cameras mounted on a unified holder, allowing simultaneous acquisition of visual and near-infrared (NIR) photographic imagery, together with stereoscopic video documentation. This enables comprehensive analysis and integration of information from visible and invisible electromagnetic spectra. Multispectral imaging is the process of acquiring images at various wavelengths to record spectral signatures - endmembers - that uniquely appear as a consequence of reflection, absorption, or emission of electromagnetic radiation depending on the composition of the object. It increases differentiation among various chromophores in biological tissue. Current uses for multispectral imaging are being seen in precision agriculture, art conservation, environmental monitoring, and biochemistry. Recent research has suggested that multispectral recording greatly enhances the detection of subtle spectral differences in tissues, greatly increasing differentiation of skin diseases. It provides accurate, efficient, and non-invasive methods for diagnosing and assessing dermatological diseases. In addition, studies have shown that the parathyroid gland is autofluorescent when excited by a near-infrared source at 785 nm and has spontaneous autofluorescence emission at wavelengths of 820–830 nm, which improves tissue differentiation compared to surrounding areas. These spectral features highlight the great diagnostic value of multispectral imaging in clinical environments. Stereoscopy, however, produces the illusion of depth through the presentation of two slightly different images, each relating to the perspective of a single eye. The human brain combines these images by stereopsis to achieve the sensation of depth. In the setting of surgical training, stereoscopic video recording greatly facilitates the comprehension and mastery of complex surgical techniques. Contemporary medical education, especially in surgery, requires innovative methods for acquiring skills due to the restricted nature of operative exposure. Ideal positioning of assistants in the operating room is often compromised by operating room spatial limitations, with practical observational experiences thus limited to a few trainees simultaneously. Consequently, the utilization of stereoscopic recordings has become an invaluable teaching tool, improving cognitive processing and learning when compared with conventional two-dimensional materials. The experimental part of this dissertation focuses on the integration of

the Mul3spect system into the operating room environment during thyroid surgery. The generated multimedia content serves as supplementary educational material, enabling detailed postoperative analysis from optimal viewing perspectives outside the operating room. The recorded procedures support ondemand, multi-user observation and contribute to a better understanding of surgical complexities. Initial experiments revealed the necessary modifications in camera configurations for closerange medical imaging. The Survey3N (OCN) and Survey3N (NGB) cameras, which were originally intended for agricultural remote sensing applications, needed modifications like macro filters to reduce minimal focal distances and polarized filters to manage glare. Additional infrared light sources were also added to enhance image quality. The original camera lenses have a horizontal viewing angle of 41 degrees and an equivalent focal length of 47 mm in relation to the standard 35 mm format, with an initial minimal focal distance of 455 cm. To accommodate the limited working distance in the operating environment, macro lenses were used to achieve sharp focus within a range of 10 - 50 cm. Ultimately, this study proposes a systematic framework - a procedural workflow - for the effective deployment of the Mul3spect system, intended to extend conventional graphical representations through the integration of spectral and stereoscopic information. Although the experimental validation is conducted in the context of thyroid surgery, the Mul3spect system is conceived as a versatile imaging platform applicable across a broad range of disciplines and fields of work.
Keywords: multispectral imaging, stereoscopic imaging, photodocumentation, videodocumentation, Mul3spect system

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