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Photogrammetry Applied to Neurosurgery: A Literature Review

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Abstract

Photogrammetry refers to the process of creating 3D models and taking measurements through the use of photographs. Photogrammetry has many applications in neurosurgery, such as creating 3D anatomical models and diagnosing and evaluating head shape and posture deformities. This review aims to summarize the uses of the technique in the neurosurgical practice and showcase the systems and software required for its implementation. A literature review was done in the online database PubMed. Papers were searched using the keywords “photogrammetry”, “neurosurgery”, “neuroanatomy”, “craniosynostosis” and “scoliosis”. The identified articles were later put through primary (abstracts and titles) and secondary (full text) screening for eligibility for inclusion. In total, 86 articles were included in the review from 315 papers identified. The review showed that the main uses of photogrammetry in the field of neurosurgery are related to the creation of 3D models of complex neuroanatomical structures and surgical approaches, accompanied by the uses for diagnosis and evaluation of patients with structural deformities of the head and trunk, such as craniosynostosis and scoliosis. Additionally, three instances of photogrammetry applied for more specific aims, namely, cervical spine surgery, skull-base surgery, and radiosurgery, were identified. Information was extracted on the software and systems used to execute the method. With the development of the photogrammetric method, it has become possible to create accurate 3D models of physical objects and analyze images with dedicated software. In the neurosurgical setting, this has translated into the creation of anatomical teaching models and surgical 3D models as well as the evaluation of head and spine deformities. Through those applications, the method has the potential to facilitate the education of residents and medical students and the diagnosis of patient pathologies.

Categories: Neurosurgery, Healthcare Technology, Anatomy
Keywords: scoliosis, craniosynostosis, neurosurgical approaches, three-dimensional models, neurosurgery, photogrammetry

Introduction And Background

The word “photogrammetry” describes the process of creating three-dimensional (3D) models from standard two-dimensional (2D) photography with measurable quantitative data [1,2].

In the neurosurgical field, the applications of photogrammetry correlate with the technique’s main functions - 3D model creation, mainly used for the visualization of neurosurgical anatomy [1-22] and for skeletal and bony deformity evaluation [23-83].

The process normally involves a series of steps, with the first one being the acquisition of the images from different photographic angles. These images then go through a process of orientation, triangulation (calculating the position of the point or object in 3D), point-cloud generation (identifying common points among the photographs), surface reconstruction (triangulation by using the point cloud), and texture mapping, where the 3D model is finalized [84]. Nowadays these steps are done by using dedicated software [1,2].

In the neuroanatomy laboratory, photogrammetry is used to generate 3D models based on cadaveric dissections [2,18,19], which allows for their repeated use and their prolonged preservation in the virtual space and their application in residents training to acquire a better understanding of complex anatomy. The purpose of the models ranges from a more general representation of anatomy [5,7,8,19,21] to the creation of collections of specific representations of surgical approaches [13-16,20,22].

The method is gradually finding its way into clinical practice with the diagnosis of craniosynostosis and non-craniosynostosis skull deformities [23-52] and scoliosis [53-83]. This is because photogrammetry offers the possibility to estimate the shape of objects and their distance from one another. Thus, numerous researchers have started exploring its use in conditions that present themselves with superficial