

NONCONVENTIONAL RADIOLOGICAL TECHNOLOGIES AND PROCESSES USED FOR NEUROSURGERY IN CORRELATION WITH INTELLECTUAL PROPERTY PROTECTION WITH DIRECT APPLICATION IN HEALTHCARE ORGANIZATION

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ABSTRACT: Nonconventional radiology systems have evolved significantly through the integration of PACS (Picture Archiving and Communication Systems) technology, which has revolutionized the way in which images captured by CT, MRI, radiology devices are stored, distributed and accessed. PACS facilitates the efficient management of radiological CT images, providing fast and secure access to patient data. This work considerably simplifies the process of diagnosis and planning of neurosurgical treatment. This IT solution can integrate and structuring medical data in an organized manner. Using this nonconventional system, human errors can be reduced and communication between specialists can be improved. The integration of this system with the neuronavigation system, represents a major innovation in the medical field. This nonconventional system allows neurosurgeons to perform complex surgical interventions with increased precision using three-dimensional images of the patient's skull. By integrating the Nonconventional PACS system, with neuronavigation, we can quickly extract detailed and relevant images from the database. This may facilitate more precise preoperative planning of neurosurgical interventions. This innovative combination is incredibly valuable in complex medical cases, where accuracy and promptness are essential. The combined use of these technologies allows a better visualization of the anatomical structures that follow to be approached surgically as well as the trajectory of the instrument used in real time. Having these landmarks reduces the risks associated with surgical interventions and may increase the operator's success rate. Integrating the Nonconventional radiology system and the PACS data network with the neuronavigation system represents an important step toward more advanced and personalized medicine. Using this nonconventional system, the quality of the medical surgical act can be improved.

KEYWORDS: Nonconventional Radiology, Nonconventional Imaging, Nonconventional Neuronavigation, Neurosurgery, Intellectual property

1. INTRODUCTION

Modern radiological nonconventional technologies have pushed the boundaries of development in both medical and industrial equipment.

This aspect has marked a significant advancement in the diagnosis and treatment of pathologies within the field of neurosurgery.

Among these, X-ray equipment, as a technique, holds a prominent position, offering a variety of applications based on fundamental physical principles. [7], [12]

Nonconventional X-ray radiography is distinguished by its ability to visualize certain anatomical

structures. This process involves the passage of X-rays through the human body or the targeted anatomical structure, [2], where they are absorbed to varying degrees depending on the density of the tissues or materials. [6]

Detectors placed on the side opposite the X-ray emitting source capture the radiation.

This process generates an image that reflects the internal anatomical structure of the targeted anatomical area.

After acquisition of images by CT radiology system, images are stored via the nonconventional DICOM protocol in the PACS system. [12]

Another significant technological advancement in the use of X-rays is computed tomography (CT). [14]

This method provides detailed three-dimensional images, obtained by collecting sequences of two-dimensional images. [5]

By rotating an X-ray generator and its detectors around the patient, precise images are acquired that allow for a more detailed assessment of internal anatomy.

The advantages of CT include the ability to provide more accurate diagnoses for certain pathologies. [9]

Another advantage is the speed of the technique, often used in emergency situations to quickly evaluate internal traumas or strokes. [6]

In recent years, technological advances have led to the development of digital radiography, another innovative method that uses X-rays.

Unlike traditional radiographic film, digital radiography employs digital detectors to capture and process images. [1], [8]

This nonconventional technology ensures rapid processing and superior flexibility in the analysis and storage of images.

Digital images can be enhanced through adjustments in contrast and brightness and can be easily shared among different specialists.

This process can facilitate interdisciplinary diagnosis. [6], [10]

Another technological advancement in the field of radiology represents the use of the PACS network associated with the neuronavigation system. [3], [8] These technologies are essential in the use of neuronavigation technology.

This is a technique that allows for the localization and increased accuracy of accessing intracranial pathological structures.

It combines data obtained from computed tomography (CT) or magnetic resonance imaging (MRI) to create a virtual guide of the patient's skull and brain during surgical interventions. By using X-rays and neuronavigation system, neurosurgeons can visualize and handle surgical instruments with precision in real-time. [10], [14]

This process can reduce the risk of damaging healthy anatomical structures.

These nonconventional technologies have transformed traditional approaches, enabling minimally invasive neurosurgical interventions with an increased level of safety and efficiency. [4], [13]

Moreover, they contribute to reducing postoperative time and optimizing clinical outcomes. The use of X-rays in neuronavigation illustrates an advanced synthesis between technological innovation and the critical requirements of modern neurosurgery.

X-ray-based equipment exemplifies one of the most remarkable advances in medical science and technology, [2], having a profound impact on the diagnosis of certain pathologies and the establishment of therapeutic approaches [13].

Nonconventional radiological technologies continue to evolve, promising even greater advancements with increased safety and efficacy across various medical specialties [3], particularly in neurosurgery.

This continuous evolution is essential to meet the increasingly complex demands of modern society. Providing innovative solutions that enhance the quality of life and ensure high standards of safety and efficiency is necessary [8].

2. NONCONVENTIONAL MATERIALS AND NONCONVENTIONAL METHODS

The use of X-rays in medical imaging has revolutionized the diagnosis and treatment of a broader spectrum of pathologies.

Recent developments in X-ray technology, the digitization of radiological evaluation processes, and the integration of images into neuronavigation nonconventional systems have led to advancements in neurosurgical procedures, [10], achieving greater precision and reduced invasiveness. (Figure 1)

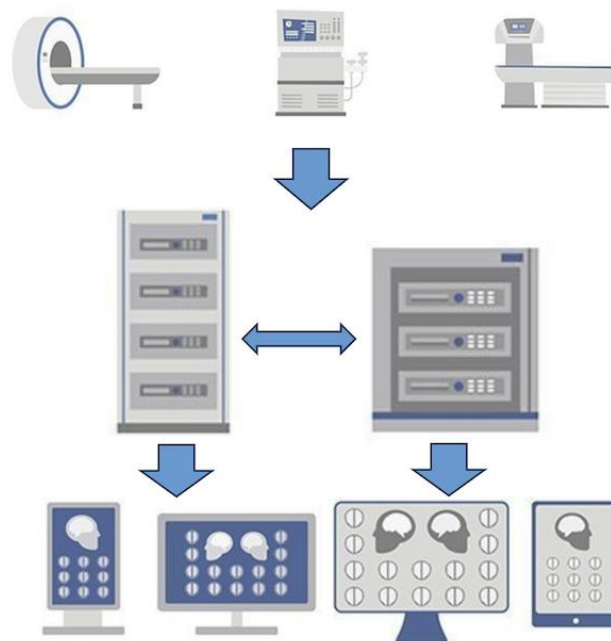


Figure 1. Schematic of the process of making and transmitting radiological images through the PACS system. (Source: Authors' own research contribution)

2.1 Acquisition of Radiological Images

This involves the acquisition of high-resolution radiological images using modern X-ray equipment integrated into a PACS network through a DICOM protocol. [14]

Contemporary technologies, such as computed tomography (CT), provide detailed three-dimensional images of pathological anatomical structures that require surgical intervention.

To achieve enhanced image quality suitable for use and processing by the neuronavigation device, well-established scanning protocols can be employed. [3], [11]

These protocols stipulate that the spacing between scanned sections should be 2mm.

The presence of certain anatomical structures, which serve as anatomical landmarks, is sought. [15]

These include the tip of the nose, the internal and external angles of the orbit, and the vertex.

Scanning parameters, such as tube voltage, amperage, exposure time, and section thickness, are adjusted accordingly each time images are to be captured for integration into a neuronavigation system. [14]

2.2 Digitalization and Image Processing

Computed tomography (CT) scan images are digitized and processed using specialized software before being transmitted to a Picture Archiving and Communication System (PACS). [9]

This process involves converting analogue images into a digital format. A subsequent stage involves various image enhancement operations. [7]

These operations include:

Artifact Correction: Elimination or reduction of artifacts caused by patient movement, sensor imperfections, or other sources of interference.

Image Segmentation: Identification and separation of different anatomical structures within the images to facilitate analysis and surgical planning.

This process can be performed manually or automatically using machine learning algorithms. [12]

3D Reconstruction: Construction of a three-dimensional model of the anatomical region of interest from the series of two-dimensional images obtained via CT scanning. [10]

This step is crucial for neuronavigation, as it allows the surgeon to visualize anatomical structures in

three-dimensional space and plan the trajectory of the surgical instrument with increased precision. [14]

2.3 Integration of Images into the Neuronavigation System

Digitized radiological images obtained via CT scanning are then integrated into a neuronavigation system.

Integration into this system can be accomplished through several methods:

a. The images are transmitted directly to the neuronavigation device's console via an internal network integrated with the radiological scanning system and the neuronavigation device. [15]

b. Transmission of images using unsecured mobile devices such as CDs or USB drives from external sources to the neuronavigation device's console (Figure 2).



Figure 2. Figure 1 Input-output slots and ports in a neuronavigation system (Source: Authors' own research contribution)

2.4 Surgical Intervention Planning

Before the surgical intervention, the surgeon evaluates and utilizes radiological images obtained through radiographic scanning and integrates them into the neuronavigation system to plan the approach path and trajectory of the surgical instrument. [3]

This planning involves identifying the surgical target, essential anatomical structures to avoid, and the optimal trajectory to reach the target while minimizing the risk of operative injury [8].

The neuronavigation system software allows simulation of the surgical intervention trajectory, providing the surgeon with an opportunity to practice and optimize the surgical technique prior to the intervention.

This stage is also known as 'surgical planning'. (Figure 3) [8]



Figure 3. Preoperative planning in a patient with a brain injury
(Source: Authors' own research contribution)



Figure 4. nGenius® Universal Tracker REF 6000-014-000
(Source: STRYKER)

2.5 Intraoperative Guidance

The neuronavigation system utilizes a set of sensors to track the position of the surgical instrument relative to the anatomical position of the patient's head, which is preoperatively fixed, and the radiological images obtained through scanning. [7]

The information from the sensors is processed in real-time, providing the surgeon with an accurate visualization of the instrument's position in relation to anatomical structures.

The surgeon can monitor the instrument's trajectory and adjust its position as needed, ensuring the accuracy and precision of the surgical intervention [13], [1].

The integration of radiological images and real-time tracking of the instruments allows for better visualization of anatomical structures in relation to the instruments used.

All these factors contribute to reducing the risk of intraoperative injuries and enhancing the quality of medical practice [10], [15].

There are several types of neuronavigation systems, each with its own advantages and disadvantages.

Some systems use optical technology, while others utilize electromagnetic or ultrasonic sensors (Figure 4) [6].

3. DISCUSSIONS

In the era of accelerated digitization, modern medicine increasingly relies on the integration of advanced nonconventional technologies to improve the quality of the medical act and promote patient safety.

A notable example represents the use of the PACS (Picture Archiving and Communication System). This radiology nonconventional system integrated with neuronavigation technologies has the potential to radically transform the way in which surgical procedures are performed.

The PACS nonconventional system allows the storage and digital access of medical images.

This nonconventional system can facilitate efficient collaboration between different specialties and streamlining the workflow in the clinical environment. Integrating PACS system with neuronavigation technologies provides surgeons with accurate and real-time information.

This information is essential for the planning and execution of labour-intensive surgical interventions. By accurately locating the intervention zones and providing a three-dimensional perspective of the anatomy of the skull and brain. These systems contribute to minimizing the risk of error and significantly reducing postoperative complications.

Neuronavigation, as an extension of digital imaging, is increasingly valuable in laborious surgical interventions.

By correlating preoperative data with intraoperative images, neurosurgeons can orient instruments with millimetric precision.

This reduces the need for large incisions and the impact on healthy tissues.

This nonconventional method leads to a faster recovery process and a reduction in the length of hospitalization of the patient.

This brings benefits not only to the patient, but also to the healthcare system, optimizing the use of resources.

In addition to the direct benefits on the surgical act, integrated radiology networks, such as PACS, play a crucial role in protecting patients' imaging data. In an increasingly interconnected operating block, secure and efficient management of this data becomes a priority.

Modern nonconventional systems offer robust security solutions.

This ensures the confidentiality and integrity of the information stored and shared among the specialists involved in the medical act.

The integrated approach not only prevents unauthorized access and possible security breaches, but also simplifies authorized access to necessary information, thus facilitating real-time decision-making.

Thus, integrating PACS nonconventional systems with neuronavigation technologies not only improves clinical outcomes but also fundamentally transforms the entire surgical and postoperative care process.

This technological synergy provides a secure and efficient platform for medical imaging management.

Thereby promoting therapeutic success, as well as patient safety and satisfaction implementing this system is necessary.

With all the technological and implementation challenges these innovations entail, their advantages are impossible to ignore and constitute a significant step towards the medicine of the future, in which precision and safety are a necessity.

Adapting new technologies (nonconventional) into contemporary medical practice underscores a shared commitment to excellence in health care, reflecting the ongoing evolution towards smarter and safer

modalities of surgical intervention, benefiting patients.

The DICOM protocol is owned by NEMA (National Electrical Manufacturers Association), which holds the patent for this format and has established it as the global standard for imaging.

The DICOM3 version, currently in use, is also known as PS3 or ISO standard 12052:2006.

The purpose of the format is to connect various equipment, such as CT, MRI, PET scanners, with servers, post-processing stations, printers, and networks from different manufacturers, providing a universal imaging „language”.

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