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Recent and Future Trends in Medical Imaging Technology, ASurvey

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Abstract: "Different typesof medicalimaging technologies are used to view the human body in order to diagnose, monitor, or treat medical conditions". Each type of technology gives dissimilar information about the area of the body being studied or treated, related to possible disease, injury, or the effectiveness of medical treatment". This report embodies different basic imaging techniques along with recent trends in these techniques. This study also enables us to understand the historical background of these techniques and the future trends in imaging techniques being used for the benefit of humankind. Currently used techniques such as X-rays, CT scan, and MRI etc. are being used to investigate various ailments such as Bone fractures, Infections, Calcifications, some tumors, Arthritis in joints, Bone loss, Dental issues, and Heart problems. Recently, the focus of medical imaging research shifted toward detail optimization and the development of new disease-specific protocols, although several striking new developments need to be highlighted. The development of new ultra-portable ultrasound devices, which make ultrasound even more attractive as a fast and low-cost imaging modality, laser-based optical imaging that uses visible or near-infrared light deserves special attention as some methods have been adopted in clinical practice. Recently, used techniques such as Optical Tomography, PET and Multi-Modality Imaging, Molecular Imaging etc. OCT is an imaging method used to generate a picture of the back of the eye, called the retina. Molecular imaging includes noninvasive detection of disease with the use of disease-associated molecular signatures. Finally, the report focuses on the future trends in imaging technologies.

Keywords: CT Image, OCT Imaging, PET

I. INTRODUCTION

"Medical imaging technologiesare usedto view the human body in order to diagnose, monitor, or treat medical conditions". Each type of technology gives dissimilar information about the area of the body being studied or treated, related to possible disease, injury, or the effectiveness of medical treatment". This concise definition by the US Food and Drug Administration illuminates the goal of medical imaging to make a specific condition or disease visible. All imaging modalities have in common that the medical condition becomes visible by some form of contrast, meaning that the feature of interest can be recognized in the image and examined by a trained radiologist. Images in the context of this report are digital. Furthermore, all imaging modalities lead to some degradation of the image when compared to the original object. Primarily, the degradation consists of blur and noise. Some fundamental principles are common to all imaging modalities, such as the interpretation as a system and its mathematical treatment. The image itself can be seen as a multidimensional signal. In many cases, the steps in image development can be seen as linear systems, which allow simplified mathematical treatment. In this report, visible area implies that the area of interest is distinguishable in some fashion from the surrounding tissue and, ideally, from healthy, normal tissue. The difference in shade or color can be generalized with the term contrast. The process of gathering data to create a visible model is common to all medical imaging technologies and can be explained with the simpleexample of a visible-light camera. The sample is probed with incident light, and reflected light carries the desired information. For example, a melanoma of the skin would reflect less light than the surrounding healthy skin. The camera lens collects some of the reflected light and most importantly focuses the light onto the film or image sensor in such a way that a spatial relationship exists between the origin of the light ray and its location on the image sensor. The ability to spatially resolve a signal is fundamental to every imaging method. The ability to spatially resolve a signal can be fairly straightforward or fairly complex. In the next step of the process, the spatially resolved data are accumulated. Once again, the camera analogy is helpful. At the start of the exposure, the sensor array is reset. Over the duration of the exposure, incoming light creates a number of electrical charges that depends on the light intensity. At the end of the exposure, the charges are transferred from the sensor to a storage medium. From here, the image would typically be displayed in such a fashion that higher charge read outs correspond to higher screen intensity. In the camera example, the relationship between reflected light intensity and displayed intensity is straightforward. In other cases, intensity relates to different physical properties. Examples include X-ray absorption, concentration of a radioactively labeled compound, or the time it takes for a proton to regain its equilibrium orientation in a magnetic field. The physical interpretation of image intensity is key to interpreting the image, and the underlying physical process is fundamental to achieving the desired contrast. As a consequence, the information encoded in the image varies fundamentally between image modalities and, in some cases, even within the same modality. The image is evaluated by an experienced professional, usually a radiologist. Even in today's age of automated image analysis and computerized image understanding, the radiologist combines the information encoded in the image with knowledge of the patient's symptoms and history and with knowledge of anatomy and pathology to finally form a diagnosis. Traditional viewing of film over a light box is still prominent, even with purely digital imaging modalities, although more and more radiologists make use of on-the-fly capabilities of the digital imaging workstation to view and enhance images. Furthermore, computerized image processing can help enhance the image, for example, by noise reduction, emphasizing edges, improving contrast, or taking measurements.

II. A BRIEF HISTORICAL OVERVIEW

X-rays were discovered in 1895.Within less than a decade, which is an astonishingly short time, X-ray imaging became a main-stream diagnostic procedure and was adopted by most major hospitals in Europe and the USA. At that time, sensitivity was low, and exposure times for a single image were very long. The biological effects of X-rays were poorly explored, and radiation burns were common in the early years of diagnostic and recreational X-ray use. As the pernicious effects of ionizing radiation became better understood, efforts were made to shield operators from radiation and to reduce patient exposure. However, for half a century, X-ray imaging did not change in any fundamental fashion, and X-ray imaging remained the only way to provide images from inside the body. The development of sonar eventually led to the next major discovery in biomedical imaging ultrasound imaging. After World War II, efforts were made, in part with surplus military equipment, to use sound wave transmission and sound echoes to probe organs inside the human body. Ultrasound imaging is unique in that image formation can take place with purely analog circuits. As such, ultrasound imaging was feasible with state-of-the-art electronics in the 1940s and 1950s. Progress in medical imaging modalities accelerated dramatically with the advent of digital electronics and, most notably, digital computers for data processing. In fact, with the exception of film-based radiography, all modern modalities rely on computers for image formation. Even ultrasound imaging now involves digital filtering and computer-based image enhancement. In 1972, Geoffrey Hounsfield introduced a revolutionary new device that was capable of providing cross-sectional, rather than planar, images with X-rays. He called the method tomography, from the Greek words to cut and to write [7]. The imaging modality is known as computed tomography (CT) or computer-aided tomography (CAT), and it was the first imaging modality that required the use of digital computers for image formation. CT technology aided the development of emission tomography, and the first CT scanner was soon followed by the first positron emission tomography scanner. The next milestone, magnetic resonance imaging (MRI), was introduced in the late 1970s. MRI, too, relies on digital data processing; in part because it uses the Fourier transform to provide the cross-sectional image. Since then, progress became more incremental, with substantial advances in image quality and acquisition speed. The resolution and tissue discrimination of both CT and MRI, for example, that today's devices are capable of, was literally unthinkable at the time these devices were introduced. In parallel, digital image processing and the digital imaging workstation provided the radiologist with new tools to examine images and provide a diagnosis. Three-dimensional image display, multi-modality image matching, and preoperative surgery planning were made possible by computerized image processing and display. A present trend exists toward the development of imaging modalities based on visible or infrared light. Optical coherence tomography (OCT) became widely known in the 1990s and has evolved into a mainstream method to provide cross-sectional scans of the retina and skin. Other evolving optical modalities, such as diffuse optical tomography, have not reached the maturity level that would allow its use in medical practice.

III. RECENT ADVANCES IN MEDICAL IMAGING TECHNOLOGY:

Medical imaging technologies have, to a varying extent, knowledgeableimportant recent progress. From the introduction of a new imaging modality to its acceptance to routine clinical practice, many years of development and testing are needed. Recently, the effort of medical imaging research shifted toward detail optimization and the development of new disease-specific protocols, although several striking new developments need to be highlighted. For example, the adaptation of phase and dark field contrast, well-known from microscope imaging, to X-ray imaging, provides a new and astonishing level of contrast in X-ray imaging and CT. One more example is the development of new, ultra-portable ultrasound devices, which make ultrasound even more gorgeous as a fast and low-cost imaging modality. Laser-based optical imaging that uses visible or near-infrared light deserves special attention as some methods have been adopted in clinical practice.Finally, improved image processing both in terms of new algorithms and of improved computing power have continually improved image quality and opened new avenues of image processing, with many new functions available to aid the radiologist in providing a diagnosis. The enormous technological progress seen in the last decades of the twentieth century gave rise to what could be called pioneering days of tomographic modalities. Invention of the transistor, the integrated circuit, and eventually the microprocessor were prerequisites for the development of modern imaging methods. During the same period of time, many of the fundamental image processing algorithms were introduced, such as digital filters or automated segmentation. Medical imaging technology benefited from these developments, and in the course of about two decades, the image quality delivered by CT, MRI, and ultrasound devices increased in great strides. In recent years, progress has become more detail-oriented, with major efforts dedicated to optimizing imaging protocols for specific organs or diseases. Two examples can serve to illustrate this trend: 1. Spiral CT (introduced in 1990 [42]): Conventional CT scanners complete one revolution to acquire a slice before advancing to the next axial slice. Spiral CT differs in that the patient table is advanced during the rotation of the source-detector gantry. The reconstruction maintains the same slice by interpolating between two successive rotations. The main advantage is that slices at arbitrary axial positions, evenoverlapping slices, can be reconstructed from the same raw data set. The development of the helical scanning principle was accompanied with improved cooling of the X-ray tube and improved detector efficiency, as well as improved gantry mechanics, which overall allowed one revolution of the gantry to be completed in one second. With such fast acquisition rates, motion artifacts were reduced, and complete volumetric scans could be completed in one breath hold. 2. Open MRI (introduced in 1992 [43]): The open MRI scanner uses a C-shaped magnet with the primary B0 field following a vertical orientation. In comparison, conventional MR scanners use a toroidal coil with a horizontal field orientation. The main advantage of the open MRI geometry is easier access to the patient during imaging, which facilitates, for example, interventional imaging. Open MRI enjoys additional popularity, because it does not expose the patient to the somewhat claustrophobic environment of the conventional magnet bore. The trend of improving existing modalities continues. Some of the progress is made by combining multiple imaging modalities, and by obtaining functional information with slightly altered imaging protocols. Optical imaging, that is, imaging with visible or near-infrared light, is a relatively young modality that is still in the development stages. In all cases, advances are being helped by progress in computerized image processing and image understanding.

3.1 Progress in Established Imaging Modalities:

3.1.1 X-ray and CT:

In recent years, X-ray imaging has reached a technological plateau. The trend away from film and toward digital X-ray imaging continues. Improved detectors with higher sensitivity allow to further be reducing exposure time and the patient radiation dose. After concerns were raised that increased use of X-rays in diagnostic and interventional procedures could lead to elevated cancer risk, a shift away from X-ray imaging toward ultrasound and MRI has been observed, leading to a further reduction of the radiation exposure in patients. Computed tomography, however, remains an attractive modality because of its very high per-slice acquisition rates, notably with the development of dual-source CT scanners [45]. Modern dual source CT scanners are capable of 0.3 s or less per rotation with an axial speed of 0.4 m/s. With such high acquisition speeds, motion artifacts cease to be a concern. In addition, the heart can be scanned in 3D during one heartbeat. Lastly, modern CT scanners give rise to sub-mSv scans. Today, radiation exposure from CT scans is less of a concern than 20 years ago. Transmission-based X-ray imaging has recently been complemented by phase contrast and dark field methods that are known from light microscopy. Phase contrast microscopy makes use of wave interference: The illumination light wave is split in two parts, a reference wave and a wave that experiences a phase delay in the object. In a similar way, X-rays experience a phase change in weakly absorbing materials [46]. With suitable diffraction gratings, the phase can be converted into intensity and thus recorded by the detector [47]. The same principle can be used to record scattered X-rays, leading to the X-ray analog of dark field imaging [48]. Phase contrast X-ray imaging provides the projection of the refractive index along the beam path, analogous to conventional X-ray imaging that provides the projection of the absorber density. Therefore, phase contrast-enhanced radiography advertises itself for CT reconstruction methods [49, 50]. These methods promise not only markedly enhanced perception of contrast, but a different type of information retrieved from the scanned object, namely, its refractive index. Particularly in conjunction with CT reconstruction methods, tissue-tissue contrast could be dramatically enhanced, thus eliminating one weakness of X-ray based CT imaging. However, the method is still under development, and it will probably take several years before phase contrast CT can be found in medical diagnostic centers.

3.1.2 Magnetic Resonance Imaging:

Magnetic resonance imaging experiences progress from the use of stronger magnets and improved amplifiers. Both lead to higher spatial resolution and improved SNR, or, with constant SNR, to shorter acquisition times [51]. A significant milestone was the introduction of a blood-oxygen level dependent (BOLD) sequence [52]. The BOLD sequence makes use of differences in T2 relaxation times between ox hemoglobin and deoxy-hemoglobin and allows to measure blood flow and blood oxygenation levels. This technique has given rise to functional MRI. Although functional MRI enjoys most of its popularity in studies to localize brain activity, clinical applications exist, including Alzheimer’s disease and the measurement of coronary blood flow. Due to its low SNR and lower spatial resolution, BOLD functional images are often superimposed over structural MRI images, similar to PET and SPECT images. Diffusion tensor imaging is another method to take MRI in the direction of functional imaging. Clinical applications include brain imaging in dementia, including Alzheimer’s disease [54]. Another “abnormal” MR imaging technique makes use of reduced T 2 as a consequence of microscopic susceptibility changes caused by bone [55]. Normally, MR is not widely popular for bone imaging due to the low proton density and the short T1 and T2 relaxation times in bone. Special sequences, such as FLASE (fast, low-angle\spin echo), make use of T 2 contrast in bones, while achieving voxel sizes between 0.1 and 0.2mm [56]. Although bone strength assessment widely relies on ultrasound and X-ray imaging micro-MRI imaging of bone promises to evolve into one pillar of trabecular structure assessment [57]. These examples highlight the present trend in MRI to extract more information from the tissue with the same underlying physical principle, but with the sophisticated application of new sequences.

3.1.3 Ultrasound Imaging:

Ultrasound imaging technology has also reached a certain plateau. Ultrasound imaging remains the modality of choice for rapid, low-cost diagnostic procedures without ionizing radiation. The size of ultrasound scanners has been reduced dramatically over the last two decades, and recently hand-held ultrasound scanners with full diagnostic capabilities were introduced [58]. It can be expected that the popularity of ultrasound imaging will further increase with the spread of ultraportable devices. Ultrasound contrast agents have been introduced that consist of gas-filled micro bubbles. These bubbles literally burst in the incident sound field and create a strong signal. These micro bubbles can be functionalized to bind to specific sites, such as tumors or inflammatory processes [59]. With such contrast agents, ultrasound, too, takes the step toward functional imaging, with the additional potential for targeted drug delivery [60] as the micro bubbles can be loaded with drugs, set to burst at the insinuated target site.

3.1.4 PET and Multi-Modality Imaging:

PET offers one potential improvement that SPECT cannot offer: more precise localization of a decay event with time-of-flight measurements, and a resulting improvement of SNR. Ultrafast electronics and fast-decay scintillation crystals are a prerequisite. For example, to achieve a time-of-flight resolution of 45mm, the detector needs a resolution of 150 ps, which is technologically feasible [61]. Moreover, experiments with semiconductor detectors are under way. The proposed detector element is an avalanche photodiode, which has a much higher sensitivity than CMOS or CCD elements, but a lower sensitivity than a PMT. Avalanche photodiode are much smaller than PMTs and promise dramatically improved spatial resolution. Combined SPECT/CT devices and PET/CT devices have been introduced more than 10 years ago [62], a technology that advertises itself, because the detectors for gamma and X-ray radiation are similar. These scanners remove the need for image fusion related to moving a patient between different scanners. Technologically more challenging is the combination of PET with MRI, and the first PET/MRI multimodality scanners became available only in the last few years [63]. Once again, the development of semiconductor detectors was crucial, because the strong magnetic field of the MRI device makes the use of PMTs impractical.

3.1.5 Molecular Imaging:

Molecular imaging can be defined as imaging of functional processes at the cellular and sub cellular scale. Traditionally, fluorescent markers in conjunction with light microscopy were used for research at this level. The concept of molecular imaging can be extended to high-resolution functional imaging with tomographic methods. SPECT and PET can be used with radio labeled antibodies or other markers that specifically interact with targeted proteins. Another emerging field links molecular imaging with stem cells: Stem cells are loaded with paramagnetic nano particles, which allows them to be traced with MRI [65]. Another related imaging technique is photo acoustic imaging and photo acoustic tomography [66]. In the case of photo acoustic imaging, the sound wave is generated inside the tissue by absorption of a high-energy pulse of light. Absorption can take place either in intrinsic chromospheres’ or in externally supplied dyes. B-mode scan techniques can be used for spatially resolving the sound source, or array detectors allow tomography-like reconstructions. One of the limits of photo acoustic imaging is light scattering, which limits the depth of the incident light pulse.

3.2 Optical Tomography:

Optical tomographic imaging modalities are those that use visible or near-infrared light for image formation. They deserve a separate section, because optical imaging currently finds its way into medical practice. Optical imaging is attractive, because it does not use ionizing radiation, has short acquisition times, offers a spatial resolution much higher than ultrasound imaging, and potentially can be achieved with low-cost instrumentation. Visible or near-infrared light experiences strong scattering in biological tissue, and common optical imaging modalities are limited to a depth of few millimeters. With the exception of optical trans-illumination tomography, optical imaging cannot rely on un-scattered photons, and reconstruction methods such as those in CT cannot be used. Optical coherence tomography (OCT) can be considered the optical equivalent of ultrasound. The light source is a special type of laser with an unusually broad bandwidth. Normally, lasers are considered to be monochromatic, that is, their emission spectrum is very narrow. Conversely, OCT lasers have a broad bandwidth, more precisely, a Gaussian wavelength distribution with a bandwidth σ of 20–100 nm. Broadband light loses its coherent properties rapidly, and a super luminescent diode has an approximate coherent length of Lc ≈ 0.44λ2/σ. Optical coherence tomography instrumentation is based on the Michelson interferometer. The sketch of a basic OCT system shown in Fig.3.1 is based on free-space optics, although OCT devices are normally based on fiber optics. In either case, the light from the SLD is split into a sample and a reference path. Light is scattered back from the tissue and recombined with the reflected reference beam. Only light scattered from the tissue section where the reference and sample beams have the same length are recorded by the photo detector. By moving the reference mirror, the depth of the detected light is changed. Moving the reference mirror therefore produces a scan of the scattered light amplitude A(z), which is the optical equivalent of an ultrasound Anode scan.

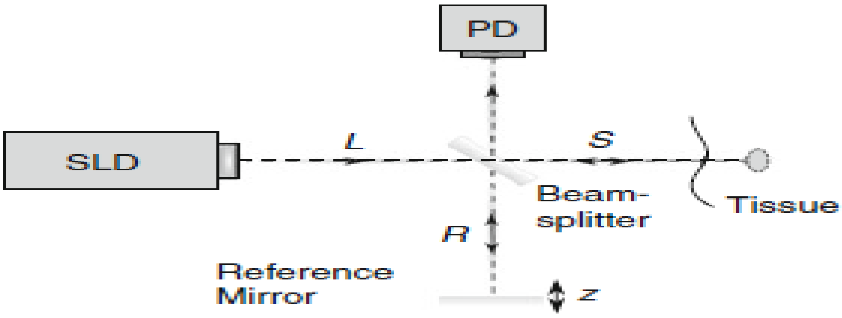

Figure 3.1: A basic OCT system.

Due to the short coherent length of the SLD, the axial resolution is high, often in the range of 5–15µm. Depending on the focusing optics, similar resolution can be achieved in the lateral direction. A scan mirror in the sample beam path can deflect the beam and sweep it much like an ultrasound beam to produce a B-mode scan. The source of contrast is the amount of light scattered by the tissue back along the sample path. Even more elegant is Fourier-domain OCT. It can be shown that the wavelength of the light contains the Fourier-encoded depth information. In other words, frequency ν = c/λ and depth z are related through the Fourier transforms. To make use of this principle, the reference arm in Fig 3.1 is movable only for coarse depth adjustment, and the detector is replaced by a spectrometer. As a consequence, the scattered signal s(ν) is resolved by the frequency. Inverse Fourier transform of s(ν) yields the scattered intensity A(z). The advantage of Fourier-domain OCT is its ability to obtain a complete A-mode scan in one measurement. Its main disadvantage is the lower SNR that is a consequence of the scattered light being distributed over many detectors in the spectrometer. OCT has found its way into clinical practice, primarily used by ophthalmologists to examine the retina [67] and less frequently the cornea [68]. In dermatology, OCT scans help diagnose skin cancer and inflammatory processes [69]. The flexibility of fiber optics also allows OCT to be used in the gastrointestinal tract [70]. Diffuse optical tomography (DOT) uses scattered photons to reconstruct the scattering coefficient in the sample. A typical DOT imaging device uses a cylindrical sample holder filled with index-matching fluid. Along two closely-spaced circles are arrayed a ring of point sources and point detectors. For a known medium and known geometry, the wave propagation equation can be solved, and the intensity at the detectors predicted. However, unlike tomographic methods those are based on straight-line geometries (CT), no closed-form solution for the inverse problem exists, and iterative methods need to be employed to reconstruct the geometry from measured light intensities [71]. The method can be modified to measure the local concentration of fluorescent emitters [72]. With fluorescently labeled drugs or physiologically active compounds, DOT holds the promise to image physiological processes analogous to SPECT and PET. The main disadvantage of the method is its poor spatial resolution. A commercial DOT-based screening device for breast cancer has been introduced recently, and DOT is in the process of being adapted for clinical practice [73, 74]. Optical trans-illumination tomography is the optical equivalent to X-ray CT. The single most difficult challenge for optical trans-illumination tomography is any form of refractive index change along the path, which invalidates the straight-line assumption of the Radon transform. In addition, the strong scattering properties of tissue require a very high dynamic range photo detector. Optical trans-illumination tomography has been proposed for several decades but has not yet found applications in clinical practice [75]. Some attempts have been made to correct for refractive index mismatch [76], but those were limited to well-defined geometries, such as tissueengineered blood vessels. However, in this context, optical trans-illumination tomography can offer unusually high acquisition speed [77]. A different approach is to use in vitro preparations that reduce the index of refraction mismatch with the application of special chemicals, and at the same time reduce the scattering coefficient [78]. This method, also known as optical projection tomography, shows very promising results [79]. However, as an in vivo imaging method, major obstacles need to be overcome before this imaging modality reaches practicability.

4.3 Advanced Image Processing:

New image processing methods and higher computing power both work together to provide improved image quality. Most of the backend image processing takes place after the image has been generated: image enhancement, detection (segmentation) of objects of interest, or the measurement of, for example, density or size of a feature of interest. However, as part of the image formation process, improved algorithms play an important role more "behind the curtains". The wavelet transform has rapidly found its place in image processing [30]. Donoho and John stone proposed powerful wavelet-based noise reduction methods [80], and many attempts have been made to use wavelet-based de-noising most notably in MRI [81], multimodality PET images [82], and ultrasound [83], although ultimately other filter approaches may prove superior [84]. The phenomenon of noise is still subject of active research. Noise reduction is a key element for further progress, because it would allow reconstruction of a tomographic image with less data, which in turn translates into reduced image acquisition times and in the case of X-ray- or radionuclide-based imaging reduced radiation exposure. With a similar goal, that is, image formation from fewer measurements, compressed sensing may become the next frontier in tomographic imaging. Compressed sensing was introduced by Candès et al. [85] and is based on the observation that sparse signals can be reconstructed far above the Shannon sampling limit. The principle is taken to the extreme in the model of a single-pixel camera, which takes a limited number of exposures to form an image of the photographed object. New reconstruction algorithms for CT [86] and MRI [87] have already been introduced. Another recent development is the more and more prominent role of computer graphics hardware in image processing. The popularity of 3D gaming has made available massively parallel processing engines [88]. In light of their raw processing power, GPUs are extraordinarily cheap. With GPU support, many vector operations can be accelerated by several orders of magnitude [89]. A typical example is arithmetic reconstruction, where GPU acceleration makes a 1000- to 2000-fold reduction of reconstruction time feasible. Hardware-accelerated versions of the time-consuming cone-beam reconstruction process in CT have also become available [90]. Similarly, hardware accelerated rigid- or deformable-body registration for multimodality imaging has become available. Clearly, GPU acceleration enables the use of more sophisticated algorithms that would be prohibitively time-consuming on conventional CPUs. The philosopher's stone of automated image processing is the automated, computerized diagnosis of a disease or anomaly from a given image. This goal is out of reach for any foreseeable future. However, the computer is still capable of aiding the radiologist in various ways, which are often summarized under the term computeraided diagnosis. The image processing steps in computer aided diagnosis are highlighted in Fig. 3.2 In conventional radiology; the image is directly displayed or printed on film. Computerized image enhancement, such as noise reduction or adaptive contrast enhancement, is a step that is often included in the digital workstation and is in itself a help for the radiologist. The computer can further support the decision process by (a) extracting the object of interest (segmentation), (b) deriving quantitative descriptors (feature extraction), and (c) proposing a classification.

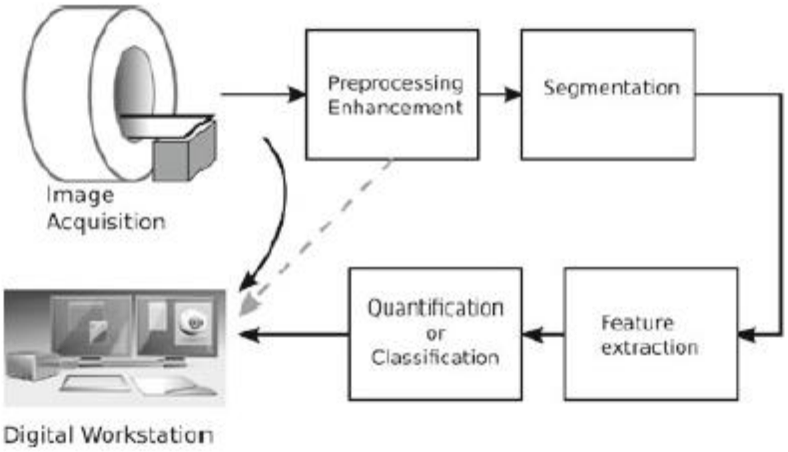

Figure 3.2: Processing steps in modern computer-aided radiology

The final decision lies with the examining radiologist. However, the computer is more and more able to provide objective data and objective measurements to support such a decision. With the development of new methods and the increasing computing power at our disposal, this trend can be expected to continue. Specifically, we can expect ongoing integration of the steps highlighted in Fig.3.2 into the scanner's image formation software. As such, the radiologist will be more and more able to rely on specific exam modules, for example, bone density or lung emphysema that complements the pure image acquisition. As a consequence, the radiologist's decision becomes more objective, can be reached in shorter time, and high-level diagnostic services therefore become more broadly available.

IV. FUTURE TRENDS IN MEDICAL IMAGING TECHNIQUE:

Medical imaging saves millions of lives each year, helping doctors to detect and diagnose a wide range of diseases, from cancer and appendicitis to stroke and heart disease. Because non-invasive early disease detection saves so many lives, scientific investment continues to increase. Let's take a look at 2019's biggest up-and-coming medical imaging technology trends

4.1. Artificial Intelligence (AI):

Artificial intelligence in the medical imaging market is estimated to rise from $21.48 billion in 2018 to a projected value of $264.85 billion by 2026, according to Data Bridge Market Research's April 2019 report. With hundreds of AI technology solutions being developed for the medical imaging market, these vendors will need to prove their ROI in a very competitive, and crowded, setting.AI has the potential to revolutionize the medical imaging industry by sifting through mountains of scans quickly and offering providers and patients with life-changing insights into a variety of diseases, injuries, and situations that may be hard to detect without the supplemental technology. Take these integrations, for example:

4.1.1 Google's Deep Mind:

The AI technology from Google's Deep Mind can read 3D retinal OCT scans and diagnose 50 different ophthalmic conditions with 99% accuracy. Also, it can not only automatically detect the features of eye diseases, but also prioritize patients most in need of urgent care by recommending whether they should be referred for treatment. This could drastically cut down on the delay between the scan and treatment, allowing patients with serious diseases to obtain sight-saving treatments in time.

4.1.2 I-CAD's "Pro-Found AI" solution:

I-CAD developed an AI-powered solution for digital breast tom synthesis (DBT), which helps radiologists to view each tissue layer independently and thereby detect cancer earlier (by 8 percent). This reduces radiologists' time spent reading breast scans by more than 50 percent on average.

4.1.3 Siemens Healthiness & Intel:

These two big-name companies are partnering together to explore how AI can improve cardiac MRI diagnostics. Now, cardiologists need to manually segment multiple different parts of the heart in their imaging which can be quite time consuming. Siemens and Intel's AI-enabled instant segmentation technology enables specialists to safely see more patients each day with the time saved via the automatic segmentation.

4. 2. Virtual Reality & 3D Imaging:

Right now, the world can't get enough of virtual reality (VR). Oculus Rift virtual reality goggles are a best seller on Amazon and there are even virtual reality arcades popping up in shopping malls that allow customers to feel the sensation of being "virtually" chased by zombies. VR and 3D imaging technologies are not only great for entertainment, but they also have important implications within the medical imaging industry. As amazing as MRIs and CT scans are, currently, their display in 2D requires physicians to use their imaginations to mentally stitch together a full picture of the 3D organ or body part. Now, new improved reality technologies, like Echo Pixel True 3D, have made it possible for radiologists or physicians to take slices of MRI pictures to create a 3D image that physicians can examine with 3D glasses, a VR headset, or even print using a 3D printer and special plastic.

4.3. Nuclear Imaging:

With nuclear imaging, a patient is injected with or without allows radioactive materials called radiotracers or radiopharmaceuticals prior to a medical imaging scan like a position emission tomography (PET) and/or a single-photon emission computed tomography (SPECT). During the scan, the camera focuses on the area where the radioactive material concentrates; showing the doctor what kind of problem exists. These types of scans are particularly helpful when diagnosing thyroid disease, gall bladder disease, heart conditions, cancer, and Alzheimer's disease. Currently, there are many exciting developments in this area; to name a few:

4.3.1. Amyloid PET imaging helps predict Alzheimer’s progression:

Highlighted in the April 2019 issue of the Journal of Nuclear Medicine, researchers have now discovered a way to better predict progression of Alzheimer's disease. Amyloid PET imaging is a diagnostic technique that determines whether patients with memory complaints have amyloid plaques in the brain, an indicator of Alzheimer's disease. Before amyloid PET, these plaques could only be detected by examining the brain during autopsies, so this type of early detection will have major implications on how physicians diagnose and care for patients with Alzheimer's disease and other forms of cognitive decline.

4.3.2. EXPLORER Total-body PET/CT Scanner:

For the first time since its first introduction in 2018, the EXPLORER human scanner (a total-body PET/CT scanner) will start to move into high-volume hospitals, for a hefty price tag of $10 million. This scanner has proven its ability to produce quality images in less time, coupled with a much lower dose of radiotracer (18F-FDG).

4.4. Wearables:

Wearable medical devices are not only a top healthcare trend this year, but they are also slated to revolutionize diagnostic imaging in 2019 as well. Two notable devices include:

4.4.1. Portable MEG brain scanner:

The lightweight MEG was developed by researchers at the University College London and is “worn like a helmet and can measure brain activity while people make natural movements such asstretching, nodding, drinking tea, and even playing Ping-Pong.” The wearable scanner brings improved imaging possibilities to patients with disorders that cause unprompted body movements, like epilepsy.

4.4.2. MRI glove:

Introduced by the New York University School of Medicine and worn next to the skin, the MRI glove can provide clear, constant images of moving joints and tendons. The new glove-shaped MRI device has been integrated with garment-like detectors, and the resulting images provide a clear map of the anatomy of the hand, aiding in everything from surgery to the design of more accurate prosthetics.

V.SUMMARY AND DISCUSSION

Among many major developments in the medical field over the past two centuries, we consider three of them of particularly outstanding importance: Out of these three, biomedical imaging is the youngest development, and its beginnings can be pinpointed to a very precise point in history, the discovery of the X-ray by C. W. Röntgen in 1895. The history of medical imaging is a fascinating topic in itself, the history of medical imaging is closely linked to the evolution of digital data processing and computer science, and to the evolution of digital electronics and the microprocessor. Medical imaging is truly interdisciplinary as it relies on mathematics, physics,computer science, biologyand engineering. This report tries to provide a solid foundation of the principles that lead to image formation. In this report, the image formation process can be followed from start to end, the source/detector systems that probe the tissue and provide the data necessary for image formation are explained. For each modality, in addition, engineering aspects of the imaging devices, and a discussion of strengths and limitations of the modality can be found. We can broadly divide the imaging modalities into two groups, those with and those without the use of ionizing radiation. Unlike visible light, high-energy photons undergo only moderate scattering in tissue and can be used to penetrate the entire body. In this report we study about various imaging technologies such as X-ray CT, MRI etc. All these techniques are used for analysis of various elements of human body, for example, ultrasound imaging uses high frequency sound waves, to create a live video feed image of internal organs. CT scan use X-rays to produce 2D cross-sectional images, or slices, of the body's bones, soft tissues, and blood vessels. Optical coherence tomography (OCT) is a frequently used imaging modality in the evaluation of glaucomatous damage. Recent advances in artificial intelligence have led to speculation that AI might one day replace human radiologists. Researchers have developed deep learning neural networks that can identify pathologies in radiological images such as bone fractures and potentially cancerous lesions, in some cases more reliably than an average radiologist. It’s a much better technology than previous approaches to medical image analysis. AI plays an important role in radiology. Imaging technology are improving diagnostic accuracy would benefit patients and physicians alike. Presently, the focus of medical imaging research shifted toward detail optimization and the development of new disease-specific protocols, although several striking new developments need to be highlighted. Imaging technology changing and challenging area in future more scope IOT based imaging technology.

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