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COMPUTER AIDED DIAGNOSIS FOR AN EARLIER AND MORE ACCURATE DIAGNOSIS OF LUNG CANCER

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ABSTRACT—The substantial workload of today’s physicians has led to an increase in false and late diagnosis. Computer aided diagnosis (CAD) has the potential to solve this problem. CAD checks digital images for suspicious areas and offers input to narrow the physician’s focus. This improves accuracy of diagnosis, assists in early detection of diseases, and reduces exam evaluation time. We will analyze the technical features and the ethical implications associated with the use of CAD for lung cancer.

CAD is an interdisciplinary technology that utilizes artificial intelligence developed by computer engineers and bioengineering image processing. We will focus on the bioengineering contribution. CAD of lung cancer follows four main steps: segmentation of lung cancer, detection of nodules inside the lung fields, segmentation of detected nodules, and diagnosis of nodules as malignant or benign.

Ethical concerns regarding software engineers’ medical obligation to patients pose a potential problem. There is also doubt about CAD’s sustainability as a technology because it needs to be continuously updated and it is not extremely cost effective. Although these dilemmas must be addressed, the benefits of CAD are worth the potential drawbacks. For example, the detection rate of lung cancer using CAD is 2.6-10 times greater than when using traditional practices. This technology has the potential to significantly benefit cancer patients because it increases the accuracy of early diagnosis, an important factor in cancer treatment.

Key words—Lung Cancer Diagnosis, Nodule Segmentation, Bioimaging, Computer Aided Diagnosis, Lung Tumor Detection

WHY COMPUTER AIDED DIAGNOSIS?

When a patient is diagnosed with late stage cancer, they begin their fight with a much lower likelihood of survival. The current early stage diagnosis rate of lung cancer is only 16%, and the survival rate for patients with tumors that have spread to organs other than the lungs is only 4% [2]. Early diagnosis is often responsible for more effective treatment and survival therefore, oncologists need new technology that will increase their early diagnosis. The concept of automated diagnosis (CAD) originated early in the 1980’s and has continued to develop since then [1]. Today it provides a potential solution to the oncology field’s problem of late diagnosis. CAD allows physicians to diagnose their patients during earlier stages of their disease, when treatments are more effective.

Considering lung cancer specifically, CAD segments each individual nodule of each lung and determines which sections are likely to be malignant. The physician can use this information to quickly find the affected sections of the lungs and eliminate time previously wasted examining healthy sections. In addition to allowing for earlier diagnosis, the use of CAD also decreases the number of misdiagnoses by using complex algorithms to determine the probability of a detected structure (nodule) being malignant or benign. Figure 1 shows some subtle missed cancer lesions (indicated by the circles), which were detected correctly by the CAD system.

FIGURE 1 [3]
An Illustration of Subtle Missed Cancers

According to The British Institute of Radiology, radiologists miss up to 30% of the affected lung nodules in chest radiographs [3]. This elevated rate of error is due to physicians’ endless workload; they simply do not have the time they need to spend on every diagnosis. CAD will solve
this problem by performing a pre-analysis of the images and highlighting specific areas for the physician to focus on. CAD is beginning to be applied widely in the detection and diagnosis of many different types of abnormalities in medical images obtained in various examinations by use of different imaging techniques [1]. For example, the use of CAD has already become a routine step when analyzing mammogram in order to diagnose breast cancer [4]. This trend should be extended to lung cancer diagnosis to significantly increase the rate of success for lung cancer treatment.

CAD is still in the infancy of its full potential for applications to many different types of detected lesions (i.e. lung cancer, breast cancer, brain cancer). Physicians across the country have started incorporating CAD into their practices. In the future, it is likely that CAD will be incorporated in all practices because of its precision, efficiency, and ability to find nodules in the earlier stages of cancer development [1].

**Why not computer aided diagnosis?**

CAD has not yet become a standard procedure for lung cancer diagnosis because there are still concerns over its sustainability and ethical issues to be addressed. Sustainability of medical technology requires the technology to be maintained as the medical field changes. As cancer evolves, CAD must evolve in conjunction and there is concern over whether this rapid development is possible. Another primary concern regarding the sustainability of CAD is its cost effectiveness. Cost effective technology is extremely productive, thereby outweighing any increase in cost. Use of CAD will increase the cost of medical practices which could increase the cost of medical care for patients. CAD can only be considered a cost-effective technology if its increase in early and accurate diagnoses outweighs these increased costs. There are also ethical concerns about involving computers in medical diagnosis and the liability of CAD’s software engineers to patients. These issues must be addressed before CAD can become widely used for lung cancer diagnosis.

**TRADITIONAL LUNG CANCER DIAGNOSIS AND DRAWBACKS**

The traditional form of tumor and cancer diagnosis relies solely on physicians’ ability to detect affected areas without the use of any analytical programs or guides. Physicians are provided only with scans such as those in Figure 1 and must determine if there are any malignant nodules present in the lungs and exactly where those nodules are located. When they see nodules in the scans, they can zoom in on the individual nodule and evaluate it to determine a potential diagnosis. The nodule is evaluated based on a database of nodules with a known diagnosis. The detected nodules can be compared to the nodules in the database by size, shape, and geometry. However, if a physician deems a scan as one with no nodules, it is discarded and the physician moves onto the next scan to determine a diagnosis [3].

This approach to locating deadly cancer cells does not take advantage of any recent technologies or methodologies of the medical field, instead it relies simply on the physician’s ability to locate and compare different nodules. Although some physicians spend years in school learning to perfect this skill, they also have other responsibilities and an immeasurable workload that continues to grow. Because of the recent increase in physician workload, less time is spent analyzing each scan and many nodules are misdiagnosed or undetected altogether. Many small nodules (like those in Figure 1) have the potential to be malignant and initially go undetected. Furthermore, failing to diagnose a malignant nodule during the first examination could mean the difference between a cancer survivor and another lost patient. Once a second scan is analyzed, the nodule may have grown large enough to be easily detected. However, it is often too late and the cancer is too aggressive to be treated effectively [3].

With the development of CAD, smaller nodules are detected at a higher rate and misdiagnoses are decreased because of the system’s precision. Utilizing this technology, a physician can detect lung cancer at a 2.6–10 times higher rate than utilizing traditional methods [1].

**CADe VS. CADx**

When examining CAD technology, it is important to note the difference between Computer Aided Detection (CADe) and Computer Aided Diagnosis (CADx). Although CADe and CADx are combined to become generally known as “Computer Aided Diagnosis”, the steps in CADe and CADx are distinctly different.

Dr. Macedo Firmimo explains in great detail the CADe and CADx processes in his article published in Biomedical Engineering Online. CADe systems are geared for the location of lesions in medical images. CADe consists of three main stages: segmentation of the lungs, detection of candidate nodules, and segmentation of the nodule. These main stages will be discussed later. The overall CADe process provides candidate nodules to the next step in which nodules are diagnosed as either malignant or benign [2].

CADx is the second process of CAD; it performs the characterization of the nodules that were detected in the CADe process. The main element of CADx is determining whether the nodules are malignant or benign. This feedback allows physicians to provide their patients with a more accurate diagnosis. Algorithms, written by software engineers, distinguish and analyze the many features of the detected nodules. These features are then used to determine the diagnosis. The algorithms take into account the geometry, shape, and size of the nodules and ultimately compute a probability of a nodule being malignant and a probability of the nodule being benign [2]. The process of CADx will also be discussed in further detail later.
COMPUTER AIDED DETECTION STAGE ONE: CADe

There are three main stages of detection (CADe). Specifically, how the lung fields are segmented, how nodules are detected in those lung fields, and how those nodules are segmented further so that they can be diagnosed. CADe is a vital part of the overall CAD process. Not only does it provide for the detection of extremely small nodules that are often overlooked by physicians, it is also necessary in order to produce the most accurate diagnosis possible. The information used to describe the process is taken from scientific journal articles written by Dr. Garth Beache [5] and Dr. Kunio Doi [1], both of whom have done extensive research on the CAD system.

Segmentation of Lung Fields

The segmentation of lung fields is the first step of the CADe process. It involves the segmentation, or isolation, of the lungs from computed tomography (CT) scans. CT scans use X-ray images taken from many different angles to produce cross-section (tomographic) images that can be viewed by medical professionals [5]. Figure 2 shows a typical initial CT scan of the thorax region.

As can be seen in Figure 2, it is very difficult to determine if there are any nodules in the lungs simply by looking at the image. Using the traditional method, malignant nodules will often go undetected. To make potential nodules easier to detect, the lungs in the image need to be segmented. Two proposed processes that are used to segment the lung fields. The first process segments the lungs utilizing deformable boundary models. The boundary models are set to the shape of the lung, and an active contour, also known as a snake, starts from some initial position on the lung and is guided by the pre-set lung shape to extract a region of interest. The pre-set shape is aligned with the initial CT data before starting segmentation with the snake. It then automatically splits into two regions representing the left and right lungs. The result is a clear CT scan of the separate lung fields (right and left lungs).

One potential drawback of this process is that the segmentation of the lungs is limited to how accurately the pre-set shape model is registered in respect to the CT image. In addition, sometimes the snake is unable to capture the natural inhomogeneity of the lung. Lastly, there are other pulmonary structures such as arteries, veins, bronchi, and bronchioles that are similar in density to lung tissue. These similarities make it hard to distinguish the lung tissue from other types of tissue [5].

The second process, which is the less common method, uses a graph-based search of a function that incorporates the intensity, gradient, boundary smoothness, and rib information of the CT scan. An intricate graph-cut segmentation algorithm based on the values of these features is applied to obtain the final 3-D image of the lungs [5].

The technology used to determine these shape models is very precise, and is constantly improving. The segmentation process results in 3-D images that are clear and easy to utilize in the next stage (detecting nodules) of the process. These 3-D images look similar to Figure 3.

Detecting the Nodules in the Lung Fields

The next step in the CADe process is detecting the nodules in the segmented lung fields. This is possibly the most important part of the process, as early detection of these nodules will increase the patients’ chance of survival. However, as with lung segmentation, some difficulties can arise. CAD systems can potentially make errors when distinguishing true nodules from overlapping shadows, vessels, and ribs [5].

The detection of nodules consists of two major stages: (1) selecting initial candidate nodules and (2) eliminating false positive nodules (FPNs) while preserving true positive nodules (TPNs). Separation of FPNs and TPNs occurs during segmentation of the nodules [5].

The main way nodules are detected is by thresholding, which is separating the background and foreground from image regions of interest. Healthy lung tissues form darker

FIGURE 2 [6]
Typical CT scan of the thorax region

FIGURE 3 [2]
Lung Scans after Segmentation is Complete
regions in the CT scan compared to other parts of the chest such as the heart and liver. Researchers have created a threshold scale based on darkness of the tissues around the lung. The lung tissues in the CT scan are compared to an optimum darkness, which is the typical darkness of lung tissue, on the threshold scale. The tissues that are not the same darkness as the optimal darkness on the threshold scale are filtered out.

After thresholding, a series of 3-D cylindrical and spherical filters are used to detect small lung nodules from high resolution CT scans. The candidate nodules are matched to template nodules that are pre-programmed. These general shapes, however, are not adequate for describing general geometry of the nodules. The general shapes are then segmented further in the next step of the process, which will determine FPNs from TPNs [5]. Figures 4 and 5 show images of detected nodules (indicated by the white arrows).

**FIGURE 4 [3]**
**Detected Nodule Potential Candidates (1)**

**FIGURE 5 [1]**
**Detected Nodule Potential Candidates (2)**

The nodules can be viewed as darkened irregular masses. As can be seen by Figure 4 and Figure 5, the nodules would be difficult to detect if physicians were to simply analyze the scans on their own, which is the traditional method of diagnosis. This is, in part, because nodules look very similar to the ribs and other tissues. The thresholding technique allows for the separation of lung tissue from the surrounding tissue to allow for a more accessible view of the nodules.

**Segmentation of the Nodules**

The last step in the CADe process segments the nodules and distinguishes FPNs from TPNs [5]. This is crucial to the goal of diagnosing tumor malignancy, which is accomplished later during the CADx process. The segmentation defines a local image area of the nodules from which image features can be used for the ultimate diagnosis. The CADx (nodule diagnosis) process requires precise segmentation whose quality will determine the accuracy of the diagnosis.

Once the potential nodules have been detected, they can be further broken down by thresholding into small volumetric pieces called voxels. The process used to determine if they are TPNs is called Discriminative Classification (DC). DC is a process in which complex algorithms created by software engineers are used to compute the probability of a voxel being part of a nodule. It uses various intensity-based features to determine the probability. For example, one feature is the density of the voxels. Nodules will have different tissue density as surrounding lung tissue, and the algorithms will be used to increase the probability of the denser tissue being a TPN. The candidate nodules with the highest probability will be classified as TPNs while the others will be eliminated and not analyzed any further [5].

One issue with the process of segmenting nodules is accounting for some cases of inaccurate volumetric measurements. These inaccuracies are caused by the movement of the patients and the motion of their lung tissues due to breathing and the heart beating during the CT scan. Researchers and engineers should further investigate these factors as they are causing small errors when calculating the volumetric measurements. However, the imprecisions of the volumetric measurements are often so minimal that they have little to no effect on the ultimate diagnosis. Therefore, the imprecisions are not currently preventing CAD from providing an overall accurate diagnosis of the nodules [5].

**COMPUTER AIDED DIAGNOSIS STAGE TWO: CADx**

After characterizing the TPNs, the CAD system will diagnose the nodules as either benign or malignant. Benign tumors are those that do not spread to other parts of the body. Benign tumors are usually not harmful, unless they are pressing on vital organs, vessels, or nerves. Malignant tumors are cancerous, and very detrimental to a patient’s health. Malignant tumors are composed of a mass of cells with unchecked growth. These tumors will spread to other parts of the body and encroach on other tissues’ intake of essential nutrients and minerals. This is why they cause so many medical problems. CADx is the second step of the overall CAD process and it is tasked with the critical responsibility
of categorizing a patient’s nodules as either benign or malignant.

**Diagnosing the Nodules**

Studies have shown a correlation between different nodule shape characteristics and their malignancy. For example, 193 pulmonary nodules were classified as round, lobulated, densely spiculated, ragged, or halo. It was found that there was a high level of malignancy (82-100%) among the lobulated, spiculated, ragged, and halo. On the other hand, 66% of the round nodules proved to be benign [5].

Furthermore, an automatic retrieval system can be used to obtain the diagnoses. A 3-D CT scan database is kept with images of pulmonary nodules with known diagnoses. The surface curvature of the TPNs is quantified as a curvature index. The TPNs’ curvature indices are then compared to the nodules’ curvature index in the database to determine the diagnosis [5].

A different diagnosis system uses the morphological and texture features of the nodules. Several morphological and texture-based features are extracted from the nodules. These features include volume, surface area, perimeter, and maximum diameter. These can also be quantified and compared to nodules in a database that have known diagnoses [5]. Figure 6 shows an example of the difference between a malignant and benign nodule.

![Malignant vs. Benign Nodules](Image)

**FIGURE 6 [1]**

**Malignant vs. Benign Nodules**

As seen in Figure 6, the shapes and sizes of the malignant and benign nodules are distinctly different. The computer-based algorithms use these distinctions to compare the nodules from the patient and the nodules from the database and determine a probability [5].

There are multiple initial ratings (between 0 and 1.0) of the probability of the nodule to be malignant. The initial rating is the rating that the physician initially gives it before passing it through the CAD system. Sometimes, however, there is no initial rating because the doctors do not actually detect the nodules in their first analysis. The next rating, the computer output, is the probability of the nodule being malignant based on the algorithms that compare the nodules to 3-D CT scan databases. The third rating, and the final diagnosis that is given to the patients, is the physician’s final probability rating of the malignancy of the nodule. This rating considers mostly the computer output, but also a physician’s comparison to a database of nodules with known diagnoses. A rating closer to 1.0 indicates a high probability of the nodule being malignant, while a rating closer to 0 indicates a high probability of the nodule being benign. If a second rating is between 0.40 and 0.60, the physician will oftentimes repeat the CAD process to obtain a mean rating with higher reliability [1].

CADx has become a novel technique for diagnosing lung cancer. In a study done in 2013 by Dr. Macedo Firmimo and his research team, the accuracy of five physicians’ who attempted to detect nodules using CAD was compared with the accuracy of five physicians who attempted to detect nodules using only traditional practices. It was found that the physicians employing CAD technology were more successful at detecting the nodules by about 13-16% [7]. CAD is more efficient, more accurate, and more opportune for doctors. However, there can be drawbacks associated with the technology.

**POTENTIAL DRAWBACKS OF THE TECHNOLOGY**

Designing efficient CAD systems is very important, since early diagnosis can improve the effectiveness of treatment and ultimately increase patients’ rates of survival. However, as with most newly developed technologies, researchers encounter obstacles.

The first major drawback occurs in the thresholding sequence of lung segmentation. Many factors affect the process, including image acquisition protocol and scanner type. A slight deviation in the darkness of a tissue in an image can make a huge difference. However, most researchers have started to use the same scanner (GE Healthcare scanners) to keep the CT scans as consistent as possible [5].

Another drawback occurs in the detection of lung nodules. It is difficult for the CAD system to detect nodules that are attached to lung borders and small nodules (less than 3 mm) [1]. Smaller nodules are more difficult for the system to detect simply because they are challenging to distinguish. However, CAD is still more effective at detecting these smaller nodules than physicians using only the traditional method. Without CAD, the detection rate of nodules between 3 mm and 4 mm is 44%. With CAD, the detection rate is 57% [7]. CAD once again proves itself as a significant improvement over traditional diagnosis methods.

Furthermore, the shape and appearance features depend on the nodule segmentation algorithm. The features are all based on quantitative measures [1]. Qualitative measures that describe the shape and appearance of the nodules with more
detail could improve the accuracy of this program and therefore diagnosis. Implementing these features is something researchers and engineers should work to design and implement in the future.

Lastly, as a new technology, CAD is still being improved and developed and there is still necessary research to be done. The databases used in detection of nodules, segmentation of the nodules, and diagnosing the nodules need to be expanded. As the technology continues to develop, larger databases for efficient validation of the processes will be provided [1]. With medical data always expanding, CAD must also evolve to become a more sustainable solution for physicians and patients alike. Another important issue is the need for a sensitive tool that can compare the segmented nodules with images from the database that are similar but not exact matches. Currently, if the nodule is not a close match to images in the database it cannot be diagnosed. Again, this issue will be solved once the technology is further developed and the databases are appropriately expanded.

These potential drawbacks, however, should intrigue engineers around the world. Engineers are concerned with problem-solving. These issues have the potential to be eliminated if the technology continues to develop and become more advanced. As with all technology, development comes with the devotement of time and research.

**PROFESSIONAL OPINIONS ON THE USE OF CAD**

Many professionals, including physicians, engineers, and computer scientists, still believe it is difficult to agree on a single benchmark to measure performance. As mentioned previously, there are two methods for lung segmentation. These inconsistencies have the potential to create discrepancies in the databases. However, the CAD system is still in its infancy. Researchers are still in the process of testing which methods of CAD are the most effective and reliable. Researchers are also still developing new scales for thresholding and new algorithms for a more accurate analysis. The databases are still being accumulated with new CT scans with known diagnoses [8].

As a result, some doctors are still hesitant about using the technology because of these incongruities. Some doctors simply use the technology as assurance to their initial diagnoses. However, the results from all the studies show that CAD is in fact more effective at detecting and diagnosing cancer than traditional methods. As the technology keeps developing and becomes even more sophisticated, many professionals in the field believe that all doctors will begin to resort to CAD as their first option in diagnosing lung cancer [8].

**CONCERNS REGARDING SUSTAINABILITY AND ETHICS**

**The Necessity for Continuous Development**

Concerns over sustainability of the technology and potential ethical dilemmas have prevented CAD from becoming part of standard medical diagnosis procedure. The main concern regarding CAD’s sustainability questions whether this technology can maintain its relevance as cancer evolves. The toughest challenge presented to those working in the medical field is its constant adaptation. An important aspect in developing medical technology is ensuring that the technology is sustainable; it must be easily adaptable as the medical field presents new challenges. Substantial amounts of research and work were required to develop CAD to its current state. However, for CAD to be effective, it must continue to develop and improve as new medical problems present themselves. CAD’s critics doubt that this level of adaptation is possible and believe it reduces the value of CAD as a medical tool. They argue that if the CAD software and technology must undergo constant improvements, the decrease in physicians’ workloads will only be replaced by an increase in engineers’ workloads [9]. Although this argument is valid, it does not account for the increased diagnosis accuracy. If CAD is successfully implemented and maintained, its main benefit will not be decreasing physician workload but increasing diagnosis accuracy and survival rate, leading to a better quality of life for patients.

**Is CAD Cost Effective?**

Another questionable aspect of CAD’s sustainability is its cost effectiveness. Cost effective technology has benefits that substantially outweigh added costs. Because medical practices must purchase and maintain CAD, costs will increase and this will most likely be reflected in the amount patients pay for their medical care. CAD has not been widely used for lung cancer diagnosis. Therefore, there is no way to determine cost effectiveness of CAD for lung cancer diagnosis specifically. However, CAD has been used more regularly for breast cancer diagnosis, and the cost of using CAD for screening mammography was investigated in a study published by the US National Library of Medicine. It was found that CAD was significantly more expensive because of the cost of the equipment and staff training. The study concluded that recall rates would need to be decreased to increase cost effectiveness [10].

This demonstrates that using CAD will increase the costs for medical practices. However, the recall rate of CAD technology for lung cancer may be different than that for breast cancer because the technology differs based on the disease it is used for. The only way to truly determine if CAD for lung cancer is cost effective is to monitor changes in cost once it is implemented. It is important that CAD is a cost-effective technology because patients could be discouraged from seeking medical care if costs are raised too high. In conclusion, if the sustainability of CAD is not improved and
maintained, it will prevent this technology from being utilized by physicians for lung cancer diagnosis.

Software Engineers’ Obligation

The main ethical concern associated with CAD is the potential obligation CAD software engineers have to patients. A physician’s obligation to their patients is an ethical question that has been debated by every society. Today, this idea still causes passionate discussion when considering topics like physician assisted suicide. Yet, most physicians are well aware of their responsibilities and liabilities. The routine use of CAD for lung cancer diagnosis would integrate software engineers into the medical diagnosis process, however software engineers’ responsibilities have not yet been explicitly determined. For example, if CAD is used to aid in diagnosing a patient and the patient is incorrectly diagnosed, leading to unsuccessful treatment, is the software engineer responsible for this error? This uncertainty in responsibility is a major problem as it could cause liability discrepancies in the future. Additionally, it is a factor deterring engineers from working with CAD software, according to a peer-review article published by The National Center for Biotechnology Information [11]. To avoid future liability discrepancies, the engineers’ level of obligation to the patients must be established.

Software engineers do have a significant impact on diagnoses produced by CAD because they create the mathematical analysis programs utilized by this technology [11]. However, CAD is only a recommendation for the physicians. Physicians ultimately decide whether or not they want to follow these recommendations. This contrast gives CAD software engineers responsibilities similar to that of a consultant. Consequently, software engineers cannot be held fully responsible for misdiagnosis. Before CAD can be fully implemented into the lung cancer diagnosis process, these distinctions in the ethical responsibilities of the software engineers must be explicitly stated. This will avoid future disputes over liability, a necessary precaution due to the extreme consequences of mistakes made in the medical field.

APPEAL TO ENGINEERS

The oncology field is in desperate need of CAD technology to improve accuracy and efficiency of its diagnosis process. Considering lung cancer specifically, CAD technology segments the lungs and analyzes each section with a level of precision physicians do not have time for on their own. This allows for earlier and more accurate diagnosis of lung cancer, which will drastically impact all patients affected by this disease. Detection during earlier stages of cancer increases the likelihood of successful treatment and survival. In addition, earlier diagnosis will allow physicians to detect cancer before it has spread throughout the body, thereby decreasing the amount of chemotherapy, radiation treatments, and surgeries patients must endure. Overall, CAD will increase survival rates and quality of life for patients diagnosed with lung cancer. This demonstrates how CAD embodies the engineering goal of developing sustainable technology to improve healthcare, medicine, and quality of life.

Another exciting aspect of CAD technology is its successful collaboration between the biomedical engineering and computer engineering disciplines. Although different engineering areas focus on distinct problems and utilize diverse techniques, all fields have overlapping interests. Biomedical engineers developed the imaging technology and techniques necessary to distinguish lesions that are often missed by physicians. Computer and software engineers developed mathematical analysis programs utilizing complex algorithms to determine the probability of lesions being malignant or benign. The combination of these developments is what allowed for the creation of CAD technology. This illustrates that there is no limit to what can be accomplished when different engineering fields combine their expertise to address society’s most important challenges.

THE FUTURE OF CAD

CAD has not yet become widely used in the lung cancer diagnosis process because of skepticism about computer involvement with medical diagnosis, debates concerning its sustainability, and unaddressed ethical issues. If these problems are corrected, it will allow physicians to utilize CAD in their diagnoses. This technology detects smaller nodules and tumors which would be missed by traditional diagnosis practices. It also differentiates subtle differences in lesion shape which indicate likelihood of malignancy. Using CAD while diagnosing lung cancer will allow physicians to produce earlier and more accurate diagnoses, two key components of successful treatment and higher survival rates. Therefore, if CAD is used routinely to aid in lung cancer diagnosis, it will save the lives of countless people who would be diagnosed too late, or inaccurately, otherwise.

SOURCES

ACKNOWLEDGEMENTS

We would like to thank our co-chair Kyler Madara and chairs Nicole McClain and Christian Ferrence for helping us to develop and organize this paper to make it more descriptive while also being succinct. We would also like to thank Barbara Edelman, who provided helpful feedback about our paper.