

Applications of Artificial Intelligence and Deep Learning in Early Cancer Detection

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Annotation: Early cancer diagnosis is a rapidly evolving area and a key global health challenge. Artificial intelligence consists of many elements from simple algorithms to complex networks, which can be applied to a wide range of potential problems. When these paths intersect, important opportunities arise. This review discusses the potential implications of this for early cancer diagnosis. The possible inferences made by an artificial intelligence system making a prediction pertinent to a mammographic finding are an important area of research and have so far received relatively little attention.

Early cancer diagnosis is a key national and international focus. In the United Kingdom, the national registry data suggest that cancer stage is closely correlated with 1-year cancer mortality. In 1-year survival is a surrogate for poor outcome, and at diagnosis there are many cancers presenting without cure in this timeframe when detected after symptoms. This underpins the national priority to improve early diagnosis rates to 75% by 2028 outlined in the long-term plan. Internationally, early diagnosis is recognised as a key priority by a number of organisations. It is

widely accepted that early cancer can have improved outcomes and the morbidity and cost associated with advanced stage disease may be mitigated. This in turn leads to a number of initiatives to investigate routes to improve early detection. Screening is one of these. Randomised trials for lung, breast, liver, colon and rectal, and oesophagogastric cancers show promising results that are being incorporated into clinical guidelines and practice.

Screened individuals are usually of high risk and follow a pathway for confirmation. However incidence screening, incidence or interval with malignancy outside the screen detected range may provide challenge even for very high-risk populations such as those with a genetic mutation, small cell lung or a subset of high foul former smokers with lung. Any programme may have to consider well as which diagnostic pathway to offer those under consideration for screen entry. Patient selection and risk stratification are key challenges for any screening programme with the definition of high-risk individuals on a population level a current problem for most cancers. In the near term, AI algorithms and software solutions may have a role in the analysis to aid in and define what the heuristics are. More broadly, AI has the potential to directly facilitate cancer diagnosis by triggering investigation or referral in screened individuals in response to clinical parameters, in which site is one component. Digital mammography in wide use and forthcoming AI applications which can be imbedded being a prototype system demonstrating this. Other areas exist where the finding is less subjective where AI could be applied more widely, such as radiomics, and the PI-RADS.

1. INTRODUCTION

In the UK, cancer survival rates are markedly lower than those in other countries with similar economies, representing a major public health challenge. The problem is most significant in those cases where in patients, cancer is found in later stages significantly in older patients. Early cancer diagnosis is recognised as a key strategy to improve patient outcomes, including in the NHS long-term plan for 2028 [1]. There are a number of efforts to that end, including the roll-out of “one-stop shops” for early cancer diagnosis, and increased use of artificial intelligence (AI) in diagnostics. Recently, great strides have been made in the application of AI to diagnostic radiology, as enabled by developments in deep learning. This has been exemplified by an ever-growing number of large-scale studies. There are also a small number of prospective trials showing benefits to patients in terms of sensitivity and specificity of radiological diagnosis. The substantial increase in the application of deep learning in the last 5-10 years has attracted a number of relevant studies: how well an AI model performs for specific tasks depends greatly on the quality of the training data. Most of these datasets consist of radiological images. The UK is unique in using a universal healthcare system with access to free public healthcare for all. This has implications for the represent ability of the training data and for the generalisability of pre-trained models.

1.1. Overview of Artificial Intelligence and Deep Learning

The National Cancer Institute notes that lung, breast, colorectal, and prostate cancer account for nearly half of all new cancer cases in the United States each year. Early detection of cancer, particularly malignancies with a high incidence rate, is beneficial for improving patient survival rates and can lead to minimum morbidity due to the need for less aggressive treatments. As the understanding of cancer biology deepens, it is increasingly realized that there are opportunities to exploit this understanding to prevent cancer from developing or to find and eradicate the disease as early as possible. Substantial resources are thus invested in the basic research of cancer biology to avert the occurrence of cancer, find a cure for late-stage cancer, or in the most optimistic scenario, discover an effective cure for the disease [2].

Cancer screening, which enables the detection of cancer at an early stage or even during preinvasive phases, has contributed to decreasing the mortality of some of the common cancers. Although the development and improvement of various screening approaches have been successful for some cancer types, the ongoing challenge is to significantly improve the early detection of other cancer types or hard-to-detect early-stage tumors. Irrespective of the screening methodology, there are often limitations to each approach that include, but are not limited to, the invasiveness of biopsy acquisition, a high false positive rate leading to unnecessary unwarranted follow-up and patient burden, inter-observer variability because of human interpretation, and the high cost of screening.

2. Cancer and Early Detection

In 2020, Cancer was the third leading cause of death globally, and is estimated to be responsible for a sixth of all deaths worldwide. Early detection is generally a pivotal strategy to reduce morbidity and mortality. Commonly cancers are detected at later stages when treatment is less effective. The development of healthcare systems and screening programmes is uneven and, in turn, can result in a stage-shift that affects overall cancer stage distribution, making further advancements in the early diagnosis harder in low- and middle-income countries. In the UK, national registry data suggest that the cancer stage is strongly correlated to 1-year cancer mortality. For most cancer types, these are an inverted U-shaped relationship between stage and mortality, with stage I and II disease (localized) being associated with lower rates. For lung cancer—frequently encountered in primary care—it has been shown that there is also a significant gradient effect between early and late stage disease; in North America, for example, 5-year survival rates following previous of stage I disease are in the range of 70 to 90%, while the latest national audit data shows lung cancer 1-year survival rates in the UK as 19% for women and 13.8% for men. Significantly, there is only a small 1% difference in the chance of cure in patients that undergone resectional cure between stage I and II disease, despite these cancers being separately in England. Furthermore, there is a far greater range in survivals between the stage I subgroups compared to earlier lower grades, with the lowest grade patients having a 93.6% 5-year survival rate compared with an 80% rate for the least advanced grades. Its audit data also show that 4-year mortality is increasing too (i.e. more patients are found at later stages) [1].

2.1. Types of Cancer

Cancer is alive since there are still cells in the host organ where this organism (cancer) grows up. Actually cancer is an organism which lives off a host organ, growing by bio-genetic-molecular mechanisms. Currently, there are around 420 different types and subtypes of cancer, so it is very important to detect cancers early, because cancer is a growing disease [3]. Symptoms of cancer, or the patient becoming unwell, appear only when the amount of cancer is already large. For this reason, death due to cancer is greater than infectious diseases. In 2018, approximately 6 million people died of cancer. Since the population and average age of the inhabitants of the earth have increased, the incidence of cancer has been increasing, and it is estimated that this number will double by 2035. The majority of new cases are expected in low-to-middle income countries (LMICs) with large, non-aging populations, as well as rapidly modernizing, smoking, and

unhealthy populations. Sixty percent of all cancer cases and 75% of cancer deaths occurred in LMICs. Even though there is a cure for early diagnosed cancer, so far, many countries, especially in LMIC, do not have the means for early diagnosis of cancer, so most of the cancer is found at the terminal stage, which results in death, as cancer grows rapidly in advanced stage [4]. As the population grows, the average age of the population increases rapidly, so cancers grow at an astonishing rate. For example, the average life expectancy of a population increases by 10 years, the number of new cancer cases will rise by 25%. Most patients who needed a hospital were diagnosed with cancer, so cancer diagnostics were considered an important field of medical imaging applications. The problem begins at the hospital due to lack of well-trained oncologists and an increasing number of people with life expectancy. Modern digital diagnostic equipment has been the most important development in medical sciences in recent years, thus allowing digital data to be obtained in clinical examinations. Changes in similar technologies cost a lot in developing countries and are not yet adopted by most countries. Co-directed X-ray images are easily available in most hospitals, thus allowing easy access to computer-aided diagnosis. The use of a computer-aided diagnosis (CAD) tool has the potential to aid in the early detection of cancer.

2.2. Importance of Early Detection

Early-stage cancer detection before disease dissemination is the central tenet of many cancer research endeavors. This pursuit is compelling because of the several-fold magnitude increase in overall patient outcomes in the setting of early-versus late-stage diagnosis. Survival increases as stage falls being particularly dramatic movements towards localized early-stage disease [1]. In this context, artificial intelligence (AI) driven deep learning strategies become an important tool in accurate and sensitive detection with the potential to ultimately improve patient survival. Screening has contributed to a higher proportion of early-stage detection of some common cancers for men, with the exception of prostate cancer, but for women only breast is detected at an earlier stage. Comparison with stage distribution from two years prior to detection, confirm the guiding screen was the first signal of cancer for only 59% of men and 87% of women. In some areas, especially low uptake programmes, efforts are being made to ensure equal access for invitations and procedures but there was no clear evidence of success. The advantages of using smoke-free products over continued smoking increase as the duration of use rises. Binary status reporting of use of tobacco/nicotine products in surveys fails to reflect the graded potential for harm reduction as smoking cessation approaches, so-called "health risk continuum". Emergency hospital admissions for asthma are associated with heatwaves of 10 days in duration at a level of 1.3°C above the heatwave threshold. With increasing global warming, more comprehensive and integrated heatwave response plans are needed to mitigate the health consequences. Paradoxically, Collectif National Réchauffement Climatique, France's main climate denialist organisation, and similar groups have gained strength in response to increasingly frequent and more destructive extreme climatic events. In women, for whom there is a perceived need to look thin to be judged as beautiful, reports of BMI embarrassment are more common: 10% of girls and 61.5% of mature women are reported commenting on someone else's body size. The obesity epidemic has been blamed for a widespread global increase in anxiety: individual fears include social exclusion, the inability to lose weight, the consequences of COVID-19, and the relentless onslaught of dieting advice in the lay media. There is new evidence on the benefits of blue spaces on mental health, with effects on older adults being greater than for younger people. [5][6]

3. Current Methods of Cancer Detection

In the past few decades, noticeable progress has been made in the diagnosis and treatment of cancer. In spite of this progress, cancer is still categorised as one of the leading causes of death in many cities around the world. Cancer is an abnormality of the growth of tissues that occur when the activities of genes, operating in cells, are interrupted. There is an emergence of cancerous cells which might spread throughout different parts of the body. If cancerous cells are detected early, this would increase a patient's life expectancy. Deep learning, a subset of artificial intelligence, play a determining role in the detection phase of an ailment such as cancer. In the past few years,

the number of machine learning and deep learning studies has grown exponentially, specifically on cancer detection [4]. This study comprised a thorough overview of computational approaches for the early diagnosis of cancer. There is a significant improvement in the cancer detection models which are discussed by employing different kinds of biomedical images like blood, MRI, and other imaging modalities.

The occurrence of the cancer disease has an intimidating threat to human lives throughout the world. The malady of cancer is not tranquil to detect, so screening is indispensable. The only cancer detection method usually through a biopsy to detect breast cancer. Artificial intelligence is a developing technology for this cancer detection method is employed in this paper. The method involves the preprocessing of image, special attention for feature extrication, and then training the image employing machine learning. After training the image identifies the prepared image utilizing back propagation techniques. In conclusion the breast cancer is diagnosed efficiently and this will upturn the lifespan of a human.

3.1. Biopsy

This study investigates a computer-aided biopsy result prediction method for general clinical applications that analyze radiology text descriptions with an automated DNN. A DNN model produces biopsy-relevant data, such as PI-RADS scores, on prostate MRI reports. The developed DNN model does not require radiologists to manually provide PI-RADS scores in order to predict biopsy results, making it practical for use with the radiology review of MR imaging studies. The model is also shown to improve performance compared to text-based heuristic rules and when additional limited pathology is provided. When trained only with radiology text descriptions of prostate MRI, a deep neural network (DNN) provides graded values of Prostate Imaging Reporting and Data System (PI-RADS) scores that are well-correlated with radiologists' readings. After training, the DNN calculates continuous scores that may be more informative than rounded integer scores, which radiologists typically report. The developed DNN model has a fixed architecture and does not require manual image segmentation. The model can be influenced by the performance of the DNN classifier, thereby providing a clear on diversification for the experimental evaluation of model that will not require feedback results from unblinded participants. [7][8]

3.2. Imaging Techniques

Artificial Intelligence (AI) is a revolutionizing technology which is adopted in the field of the medical imaging to provide more reliable, repeatable and quantifiable results. Deep Learning (DL) has expanded human understanding by recognizing patterns in complex data which nestles surrounded by the neural network. The main objective of AI is to detect cancers as early as possible and track their progression over time using readily obtainable medical imaging data [9]. With the rapid development of the artificial intelligence, deep learning was introduced as a subset of machine learning and started dominating the medical imaging field. A widespread implementation of deep learning cancer imaging for the computer-aided detection system is due to obtaining more accurate outcomes and due to successful implementation in the early detection of breast cancer, lung cancer, and glioma cancer [10].

Cancer as a life-threatening disease has always been a threat to humanity. Detection of different types of cancer as early as possible is very important to treat and cure cancer. Hence, pathological and non-pathological images are analyzed using imaging techniques such as X-ray mammography, ultrasound, CT, MRI, etc. Early detection of cancerous cells in anatomical areas could provide a more favorable outcome. Therefore, there are various cancer imaging surveys conducted for different anatomical areas and different image techniques. A significant rise in the previous two decades has been observed in significant advancements in cancer imaging techniques. On the other hand, machine learning (ML), especially deep learning (DL) network plays a prominent role in the computer-aided identification of cancer that is detected in medical images. As a new deep network approach, CNN was developed for the computer-aided detection (CAD) of cancerous cells in the 1990s. In subdivision, different authors investigated and established notable breakthroughs for

CAD and early screening of cancer.

4. Artificial Intelligence in Healthcare

Technological developments in the past few decades have brought significant enthusiasm in the healthcare sector [2]. Among recent technologies, artificial intelligence together with deep learning (AI&DL) have been introducing advanced solutions for early diagnosis and effective treatment of diseases. Artificial intelligence is the hottest trend in technology that has urgent public health demands. In healthcare, the interest in AI technologies is witnessing exponential growth. Volumes of traditional and digital medical images and signals are generated and archived daily. On the other side, the DNN approach is advantageous in the discrimination of complex multi-featured information pattern from digital input signals. Recent research by considering the conventional conciseness of the essential use of AI in healthcare; a short, concise, and informative bibliographic report with a focus on this topic is presented. The realization of early cancer detection is an important goal for successful treatment and improved patient lifestyle. Oncology is heavily reliant on medical imaging for definite diagnosis, identifying primary tumors using computed tomography, magnetic resonance imaging, ultrasonography, and positron emission tomography images. Although physicians are provided with sophisticated medical images, it is still perplexing to detect or distinguish certain cancer situations [3]. In a clinical setting, owing to the bio-genetic-molecular mechanism, cancer is a live asymmetric organism, which tends to subsist off the host organ, presenting a subtly dim and murky appearance at a relatively early stage of expansion. In the search for other tissue sites, aggressive malignant cells invade the vasculature or the lymph nodes first. As a second step, remote cancer cells transfer and create secondary colonization. Comprehensive medical treatment and elimination of tumor cells are still reachable and can result in a complete cure if detected at the early stages of expansion. Six million people died of cancer in 2018. The frequency of cancer is biologically supposed to at least double by 2035, predominantly in middle-income developing countries. An expanded incidence of carcinogens, including urbanization, gestation, and demographic shifts, and extended life expectancies have added to this circumstance. Most patients in developing nations are diagnosed so belatedly that the prevalence is too onerous for prolonged therapy. Traditional cancer detection strategies are not being emphasized by physicians in non-industrialized nations. At least 85% of disparities in cancer detection within countries are due to the unavailability of adequate detection. In the early stages, the general biological region can give rise to little comprehension. The clinical importance arises in the context that the classification of incipient focal lesions or the spatial description of violation patterns can undergo significant treatment or observation changes. Despite efforts towards developing non-invasive imaging procedures to accurately delineate primary tumors, several challenges persist. AI and radiomics should improve patient diagnosis and lead to better-informed decisions relating to detection, prognosis, and treatment. To begin with, the ability of doctors to shrewdly ascertain subtle distinctions from medical images may differ due to all sorts of factors such as destiny, taste, and complexity. In addition, due to the occult location, small size, or the masked appearances of the tumor, obviously, it is difficult to detect some primary tumors in the early stage. Third, the correct quantitative judgment and size of the tumor is crucial in medical decision. Some appearance changes after tumors are subjected to treatment, such as radiofrequency ablation, radiotherapy, or chemotherapy, making it more demanding clinically to decide the extent of cancer cell remaining.

4.1. Benefits and Challenges

Innovations in the detection of early cancer are likely to have some of the greatest benefits for public health in the coming years. However, implementing these detection methods at scale in the most effective way is a substantial challenge. Under-detection at an early stage can be addressed by screening approaches. Large-scale population screening programmes offer the potential to leverage this early disease state for better patient outcomes. Various forms of screening for cancer already exist, from the relatively simple breast cancer mammography screening to the highly structured and invasive bowel scope programme, but the majority of UK cancer sites have no

population screening programme currently available. Further, the evidence supporting the introduction of new cancer screening programmes must be generated through careful well-powered trials to avoid over-diagnosis, false positives, and other unintended harms [1]. There is therefore the desire and need for other innovations to be able to detect cancer at an early stage.

Early cancer diagnosis and artificial intelligence (AI) are rapidly evolving fields with important areas of convergence. The AI strategy released by the Department of Health and Social Care describes early cancer detection as a primary goal of the UK AI health programme, suggesting the AI-based technologies are about to become a major component of future cancer diagnosis systems. Given this changing landscape, it is essential to understand the benefits and appreciate some of the challenges faced in using AI to develop and potentially implement this emerging technology in the detection of early cancer. Here the state of AI in the context of early cancer detection is summarised, and an overview of how it might be implemented and its impact is provided.

5. Deep Learning in Healthcare

Early detection and timely treatment of cancer can increase the chance of patient survival. However, early detection of cancer is difficult due to the unavailability of necessary screening equipment in poor regions and the need for additional invasive tests in the detection process. Since the medical image analysis field is broad and some cancer-focused image analysis literature can be missed, this survey paper aims to cover deep learning and its application in selected cancers from the modality of medical image analysis. As a result, this survey paper can be a practical reference on deep learning for selected cancers in addition to being a scientific contribution to the surveyed field. Since earlier detection improves survival after cancer diagnosis, a timely screening test is needed. Biopsies are the best practice for diagnosing cancer. However, biopsies are very aggressive. For this reason, significantly less invasive tests are used for early detection.

In the screening goal, the imaging test is the best choice because it is performed externally. Then, most types of cancer use the analysis of the medical image method for the diagnosis, while breast screening uses the mammography type of image. For this reason, early detection for breast cancer and some other types of cancer is possible in addition to early diagnosis. Since the type of cancer that will be considered is the analysis of the method of medical image, the ultrasonography modulus of this survey will focus on selected cancer types namely Breast Cancer, Cervical Cancer, Brain Tumor, Colon Cancer, and Lung Cancer along with breast screening methods, Pap smear screening methods, the colonoscopy method, CT scanning method of lung cancer, and ultrasonography screening method of a brain tumor for a better understanding of the screened cancer types using medical imaging. [11][12]

5.1. Convolutional Neural Networks

Much research has been done on the detection and diagnosis of breast cancer for women worldwide. Breast cancer is an uncontrolled growth of cells that initiate in the breast tissues, mostly in the inner lining of milk ducts and occasionally in the lobules that supply the ducts with milk. Thus, this malignancy may spread towards other parts of the body. This breakthrough statistics aims to estimate 280,000 cases of women developing new breast cancer, 100,000 obesity cases, and 22,105 death occurrences at the US in 2021. Consequently, recent developments in health research are focusing on early-stage detection to reduce mortality rates and thus preventative measures should be taken care of. Breast lesions are sometimes detected on mammograms, which is an x-ray based imaging technique used for the early prognosis of breast cancer before the physical symptoms. Mammograms sensibly form weaker contrasted images of soft breast tissues, where dense and glandular tissues have strong light intensity due to the radiation, whereas fatty tissues have a low intensity, making it tougher for the professional radiologist to analyze any suspicious mass lesions. The development of computer-augmented mammography diagnosis tools, capable of automated mass detection and biopsy recommendation, enhance early breast cancer detection, has become a line of intense research effort for the past few decades.

Deep learning has a burgeoning talent in computer-aided breast cancer prognosis. [13] have discussed malignant and benign breast lesions identified by the Wide Mass Survival team in the digital database of mammography cases. Due to the irradiation of women from the U.S, the GEE distribution is considered to create three clusters on decision boundaries. Consequently, a suitable methodology for detecting or predicting breast masses is determined. Due to the high-performance capability of deep learning, a deep convolution neural network (DCNN) with inception blocks and features stretching is implemented. To optimize the CNN architecture, multi-objective clustering is also applied, focusing on physical representations. The deep network performance is evaluated using the DDC as the positive example data set and the Mammogram Image Analysis Society data set as the negative example.

5.2. Recurrent Neural Networks

Early cancer detection before cells become malignant has shown a potential mortality reduction in different types of cancer. The application of deep learning in cancer cell analysis and classification has become a field of interest in late. The application in different cancers such as breast, esophageal, lung, and prostate cancer has shown a high potential for early and accurate detection of cancer cells in medical images [10].

The application of deep learning in early cancer detection of breast, esophageal, lung, and prostate cancer is thoroughly reviewed. Breast cancer has a high incidence and mortality rate in women worldwide. Computer-Aided Diagnosis (CAD) has been applied to automatically analyze breast cancer from mammography images. Different deep learning models, particularly CNNs, such as VGG, Inception, and Xception, are applied to classify benign and malignant mass. Researchers have assessed an average accuracy of 83%. X-ray imaging remains the most popular method for lung related cancers. A CNN-based Multi-Instance Learning (MIL) approach has been proposed to classify chest x-ray cancer images. Researchers have evaluated the performance of a pretrained AlexNet model with an average area under the curve (AUC) of 87.4%. In Esophageal cancer, U-Net with a dice coefficient of 0.76 were developed to detect early cancer of esophageal lesions from endoscopic images. Further, in situ esophageal cancer model yielded the sensitivity of 0.625 with the false-positive rate of 3.8766 per image. The Xception model detected 158 prostate glands while the proposed model detected 170 glands. This result confirms the proposed model is more effective in detecting cancer glands as it detects more glands accurately. Deep learning is applied for follow-up mammography tests. Simulated tumors with and without mass were used to train 6 different architectures with a transfer learning approach. The inception v3 model has the highest tumor prediction sensitivity of 33% followed by ResNet101 and DenseNet201 with 30% sensitivity each among the detected.

6. AI and DL Techniques in Cancer Detection

Despite the rapidly increasing number of patients diagnosed with various cancers, the 5-year survival rate and quality of life have improved owing to timely and appropriate treatment. At early stages, the optimal treatment choices increase with an increase in overall survival rates. Cancer screening has contributed to decreasing the mortality of some common cancers. The most successful examples are the identification of precancerous lesions where treatment leads to a decrease in the incidence of invasive cancer. Moreover, the population is aging rapidly, further increasing the global burden of cancer. Automation is being used to supplement doctors' expertise and improve the efficiency of cancer screening.

For a DL classifier for p16/Ki-67 dual-stained cytology slides trained on biopsy-based gold standards, DS showed AI-based DS had equal sensitivity (56.0%) and higher specificity (83.8%) compared with a Pap smear (63.7% and 76.0%). For a DS model with high sensitivity using a small number of slides, the AI-based DS reduced unnecessary colposcopies by one-third compared with Pap smears while demonstrating a similar performance in identifying high-grade CIN [2]. A trial of 10,149 average-risk patients showed that AI-assisted colonoscopy significantly increased the adenoma detectors rate compared with conventional colonoscopy (ADR 29.1% versus 20.3%).

A 1% increase in the ADR is associated with a 3% decrease in colorectal cancer incidence. With the integration of smartphones and smartwatches, US companies have developed commercial medical products that can automatically analyze images for the monitoring of diabetes and glaucoma.

In the future, healthcare AI is anticipated to be more commercialized, for applications including the triaging of patients in emergency rooms, automated interpretation of medical images, analysis of laboratory tests, predicting disease progression, identification of treatment options, early detection of systemic diseases, and minimizing insurance fraud. In many cases, patients are treated with complexity rather than with a single condition. Through the integration of AI with genomic, laboratory, and real-world data, AI techniques can help faithful practitioner. More and more patients require the application of AI to optimize disease monitoring and treatment.

6.1. Machine Learning Algorithms

Early detection of nodules on computed tomography (CT) is critical in identifying patients with lung cancer at an operable stage. Detection of earlier stage cancers results in a longer potential time to treat, a greater chance of successful treatment, and a smaller burden on healthcare resources. As such, there is significant interest in developing Artificial Intelligence (AI) algorithms to aid radiologists in the identification of these nodules. In the UK, driven by the NHS Long Term Plan, the overall detection rate of screen-detected lung cancers is less than 3.1 of each 1,000 people screened. Thus, there is scope to increase the detection of malignant nodules. Further, the over-referral rate, evoked by the use of fixed-diameter cut-off points, remains high. The target condition detection rate (TCDR) of lung cancer screening to date is 6.3 of each 1,000 people screened. The Detection of Active Nodule Growth on CT as a Surrogate Endpoint for Lung Cancer trial is a large (n=15,083), multicentre, randomised-controlled trial to evaluate the accuracy of the Lung Cancer Probability Convolutional Neural Network in detection of screen-detected lung cancers in the interim screening rounds of the UK Lung Cancer Screening pilot. The secondary endpoint is assessment of the LCP-CNN's impact on the over-referral rate with respect to fixed-diameter cut-off points. Additionally, the LCP-CNN's ability to detect lung cancer in initially missed nodules will be assessed. Applicability to incidental extracolonic findings will also be explored. The trial represents the first step towards demonstrating the role of AI in the first national lung health check programme. Given that detection of radiologically indeterminate nodules places significant burden on the wider health services, the methodology and feasibility of the trial will be discussed in detail. The trial has met all pre-defined progression criteria set by the Independent Trial Steering Committee, and recruitment will occur in two parts: initially, n=2,000 individuals will be recruited to train and internally validate the model. [14][15]

7. Datasets and Data Preprocessing

Early detection of cancer through artificial intelligence has become an important aspect in health care, as it contributes to a reduction in cancer related deaths. Among the different types of cancer, those in the liver present with very low rates of recovery, therefore this study focuses on the early detection of liver cancer. A convolutional neural network that selects areas of interest through object detection is proposed to detect liver cancer. The database consisted of 9,611 patients, of which 728 were diagnosed with liver cancer. Data was collected from women on the size and cancerous symptoms of the liver, the presence of hepatitis, as well as substances related to the liver in the blood. Data was collected from men on the size and cancerous symptoms of the liver, the presence of hepatitis, and the presence or absence of cirrhosis. The preprocessing for both databases was carried out in the same manner: removing null data, normalization, one-hot encoding for the categorical data, and data division. The proposed model consists of a GoogLeNet pre-trained network for feature extraction with transfer learning, a Region Proposal Network, and an object detection model that selects the image area needed to make predictions with Faster R-CNN. The results of this model, which was validated on the test set, were the detection of the cancer area with 0.68 in IoU and cancer detection F1 score of 0.55 for women, and 0.84 in IoU

and cancer detection F1 score of 0.48 for men. These findings suggest the proposed model as a method that would contribute to the early detection of liver cancer by providing doctors with areas that may contain cancer [16].

7.1. Publicly Available Datasets

The research of this comparative study to develop innovative algorithmic models for lung cancer detection from computed tomography (CT) scan images used datasets that are available to the public. These public datasets consist of Computed Tomography images, patient's report, Clinical trial information to conduct lung cancer research and develop advance AI assisted models under data reuse guidelines. Detection and diagnosis models for malignancy of CT scan images in lung health under public datasets were evaluated. This benchmark study can guide future researchers and developers for the lung health dataset-related design, model improvement, and clinical adaption [17].

Lung cancer is the leading cause of cancer-related deaths worldwide, and early detection is critical for survival. As new public datasets have become available, the timing is right to conduct a comparative study on the detection of small pulmonary nodules in chest CT images across public datasets to better understand the generalizability of detection models. With the increased optimization and investigation of the diverse Full-Union models, the comparison provides a comprehensive picture of deep learning models' performance on detecting pulmonary nodules across multiple public datasets, including a dataset from a clinical trial.

8. Case Studies

Identifying and mapping various aspects of a field of study is broadly recognized for comprehending its outputs, solution methods, accomplishments, and problems. Developing medical imaging devices, such as computed tomography (CT), magnetic resonance (MRI) and positron emission tomography (PET), has boosted the rise of scientific journals on medical imaging analysis in oncology settings, and this upswing has been accentuated by the quick dissemination of computerized image analysis. In oncology settings, technical devices generate a substantial amount of radiological images, but actually interpreting those images may be a challenge for health or medical doctors, i.e. radiologists or oncologists. Detecting cancer is complex and non trivial because fundamentally it is an organism which lives off a host organ, expanding by bionano-genetic-molecular components and mechanisms. It is an intricate task for industrialized and for state-of-the-art countries, but-dealing with the growing case-mortality rate of the disease-seems to be an insurmountable hustle for low-to-middle income countries (LMICs). In 2018, 18.1 million new cases worldwide were identified, thus boosting it into one of the major lethal sicknesses [3]. According to WHO, 6 million people died in 2018 and its occurrence is projected to double by 2035. LMICs are an area that is primarily vulnerable to radiologically detectable cancers; actually 60% of new cases are diagnosed there causing an excessive load on their health system; furthermore, 75% of the deaths occur there despite the uncommon occurrence comparing to the industrialized countries. One of the crucial clinical struggles in cancer imaging analysis is the specific discovery and distinctive characterization of cancers [4]. As a non-invasive modality, between the medical imaging techniques, CT has long been applied in oncology settings from the early stage of diagnosis for the purpose of differentiating between concern and benign tumor in various preferences. Unquestionably, visual interpretation by dedicated radiologists is necessary for the qualitative interpretation of cancer imaging satisfying the clinical requirement. Technically, artificial intelligence (AI) has the ability to robustly handle the challenge of cancer imaging, and clinically so that it can assist in the qualitative interpretation of cancer imaging by the specialized doctors. Two specific cases about AI applied on Lung and Breast cancer imaging are shown to demonstrate the possible potential of this AI applied imaging modality.

8.1. Breast Cancer Detection

Breast cancer is the second most common cancer globally and the fifth leading cause of cancer

death among women worldwide. One in eight women (around 12.5%) will be diagnosed with breast cancer during her lifetime. Regular screening tests are the best way to detect this cancer early, and these tests can detect when the cancer is most potentially cured. Early detection of breast cancer and advances in therapeutic procedures establish an elevated role for ensuring prolonged survival rates. To validate the proficient early recognition process, this need-based article pursues the reviewed literature on computer-aided diagnosis for breast cancer classification using deep neural networks and transfer learning. Further considerations the artificial intelligence implementation for breast cancer detection embedded secure and precise results in mammography and digital breast tomosynthesis modalities are discussed [18].

Breast cancer can present in various ways, and it can be challenging to make a precise diagnosis. Additionally, the complexity and higher occurrence of benign disease states make it hard to consistently relegate readouts from mammograms that are typically displayed in black-and-white. Deep learning (DL) has shown encouraging results in various intrinsically image-based domains and outperforms classical machine learning (ML) methods when suitable data is afforded it. Until recently, DL performed better when matching a larger symptom to a larger model, but this often also resulted in unstable training. This method of transfer with unsupervised pre-training was typically contrastive learning. With specific consideration to this system, it will be explored the ways in which unsupervised input training or supervised contrastive learning may reduce the diagnostic performance variability across readers [19].

9. Ethical Considerations

1. Introduction Health care providers, researchers, policy makers and industry are dramatically expanding the use of artificial intelligence (AI) and machine learning technologies for health care tasks, with a focus on diagnosis, prognosis and treatment planning of serious diseases, such as cancer. Aspiration, expectation, funding and development timelines for Artificial Intelligence (AI) in healthcare have moved on since this paper was conceived in late 2016. Currently, partnerships between Google Deepmind Health, NHSTrusts, Cancer Research UK and universities in the United Kingdom are developing and testing machine learning technologies to augment or expedite mammogram readers' work [20]. In parallel, governmental, intergovernmental, professional and industry statements aimed at or expressing Ethical, Legal and Social Implications (ELSI) of AI noting excitement at the potential benefits of AI, but also concern about potential harms and risks are proliferating. The possible adverse consequences of AI to be discussed herein are particularly concerning in the context of ultra-violet (UV) detection because, as with population level continuous monitoring in housing settings for example, these use-cases represent major upscaling in the number of individuals screened, and entail analysis by so-called 'black box' systems. There is however much conceptual and terminological imprecision in public discussions about AI. The popular AI debate continues to be dominated by Artificial General Intelligence (AGI) or strong AI, a far off future possibility of machines that are sentient and conscious, and that can understand the world and learn tasks like humans. However, an important shift in AI development has occurred, especially since 2006. Early clinical decision support systems using AI techniques (CAD) utilized a monolithic framework, typically relying on expert system techniques and knowledge hard-wired into the system. Broadly this paradigm can be termed 'classical' or 'old AI'. It required humans to provide explicit rules to the system. Shifts in the incentive structures and data access mean that the vast majority of contemporary research on further developing and validating AI for detection focuses on a monolithic, but notably black box, classification system. In contrast, 'new AI' is characterized by the use of novel machine learning techniques and requires a non-domain-knowledge-expert human only to process the database and make law-like rules for the automated logic engine. These techniques enable an algorithm to evaluate new databases and independently classify and cluster the available data, regardless of human knowledge or understanding. Deep learning techniques, in contrast, are data driven and inherently complex; the algorithm is a learning architecture with adjustable weights that approximates the desired output following example inputs. Long considered, but only recently feasible widescale AI development

occurred further to the collection and study of 'big data', and advances of complex computer algorithms make complex inferences about these data, leading to the growing popularity of such technologies in many domains including healthcare. By design these algorithms have the capacity to develop the ability to identify subtle, abstract or diffuse patterns in the data. Over time, and crucially independent of explicit human instruction, the algorithm 'learns' to identify and selectively extract relevant attributes from the data. Assuming any development primarily for diagnostic, rather than prognostic, use, the collected data size will reach a critical mass where it exceeds human understanding, just as it is envisaged to, and has already been shown to, exceed current theoretical frameworks – whilst regulation can set the boundary conditions of the learning system design, numerous hyperparameters in the analytic pipeline itself falls outside of this. The binary output will be generated solely on the data attributes processed by the system, rather than any physical properties of the actual biological process depicted in the data. The learning system, the database it was trained on and the database it is evaluated on need to be both static and, to enable widespread scaling within healthcare systems, highly standardized. Given the need of vast volume of tagged data to train from, such a collection may occur in a range of institutions where data format, quality and detail vary. Far from being rare exceptions, it is the typical case for the learning system to have no transparency into how its output was derived from data. Thus, the learning systems in their current form would be uninterpretable to humans. [21][22]

9.1. Privacy and Data Security

Today, with the explosive development of artificial intelligence and deep learning technologies, the detection and analysis algorithms of early diseases based on medical imaging have greatly improved. A large number of studies have shown that with the assistance of artificial intelligence algorithms, the analysis and diagnosis speed of early diseases can be increased by up to 3 or 4 times, and the accuracy rate is higher than that of human analysis. Therefore, the application of artificial intelligence and deep learning on early screening of cancer has become a trend in the medical field. Traditional early screening methods for cancer mainly include pathological analysis, biochemical tests, X-ray radiographic examination, and manual assisted examinations. However, traditional screening processes may be missed due to the visual fatigue of physicians and the lack of a large enough sample basis, or due to inaccurate decisions leading to missed screening. Therefore, the artificial intelligence and deep learning algorithm models based on medical imaging, that have emerged in recent years, have been applied to the early detection of diseases [23]. The purpose of this paper is to introduce the imaging principles and advantages of artificial intelligence and deep learning, and also to explain its application principles in the early detection of cancer. Moreover, this paper also details the three mainstream deep learning models under artificial intelligence for use in the medical field. The understanding of "artificial intelligence" in this paper specifically refers to the technology and methodology surrounding deep learning in AI.

10. Future Directions

The LUNG Screen AI study is the first prospective evaluation of the LCP-CNN in detecting small lung nodules. Pre-specified nodule location will be marked up into the LCP-CNN before and after training to explore learning effects. The target population is at intermediate risk of lung cancer or 27.5% per criteria. This is the fourth round of a regional screening trial in Orillia, Ontario. Current nodule management best practices recommends screeners mark up nodule locations for volumetric nodule measurement on the initial scan. However, this is not always done and not possible for deep-seated nodules. n CF and CT image findings are integrated to generate a lung cancer probability (LCP) score for screen-detected pulmonary nodules [1]. A deep or large nodule model is reviewed for screen-detected pulmonary nodules that are not or poorly appreciated on CT image alone, respectively. For training purpose, screeners will post its expected nodule management onto ProCure on screen detection of a non-calcified nodule and before the next scan to minimize bias. Half of the nodule location is randomized to be marked up into the LCP-CNN for the first screening. Screeners' performance will be adjusted after learning the LCP-CNN as the nodule markups will only be shown to screeners before nodule size is reported on the first plan scan and

overall effect is explored [2].

10.1. Integration with Medical Devices

Artificial intelligence (AI) and deep learning (DL) have shown performance that is competitive with human doctors in some medical screening tasks. Given the ability to analyze millions of imaging or nonimaging data points, deep learning typically has significantly higher sensitivity for certain tasks compared with human doctors. For integration with medical devices, several commercial microscopes and slide scanners have integrated AI algorithms for specific screening tasks. Broad adoption of AI and DL in such field- and task-specific devices that perform medical screening tasks is likely to be successful in the near future [2]. The prediction is based on the successful examples of AI-assisted DS or CAD algorithms that have been used clinically for some cancer screening tests. Preventive medicine requires a large number of screening tests to detect diseases at an early, treatable stage. In some countries, it is not unusual for the elderly to annually undergo multiple screening tests for several common cancers. Moreover, more advanced technology and tests are usually preferred if they have been verified through multinational testing or through publication of clinical guidelines by a medical society. These factors result in recurrent business opportunities for the screening test and genetic testing market.

11. Conclusion

At the beginning of the 20th century, cancer was rarely seen in the life cycle, but it now represents a significant population burden due to the rise in life expectancy and lifestyle changes. However, the cure rate may still be great if the disease is diagnosed in the early stages. Accordingly, the innovation of non-invasive early diagnosis technology is a vital phase in cancer control and will positively overwhelm this worldwide health concern.

To detect benign or malignant nodules on screening low-dose CT, a lung cancer prediction CNN model was discovered that could be applied as an additional part for the radiologist's review. The model had acceptable performance and enhanced performance to radiologists in the stratification of feared benign and disallowed nodules while holding NPV high. By describing the creation of novel DLMs such as volumetric Bar-CNN models, DLMs had only become known chiefly for similarly assessing gainful outcomes from the LCP as intended. Additionally, such DLM does not exaggerate the pros of LCP [2]. A great strength of using a develop and reasonable AI-DLM in the experimental setting is with an unbiased selection of LRNDs to screen observe verrucous nodules. The identification and review conducted by the radiologist would significantly affect this and any DLM study. Other analytical and imaging methods of the RND modeling, such as the radiophonic of the nodular structure or calcification could augment the outcome of the artificial intelligence examination. Future work could reassess AI-DLM in these additional surroundings.

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