City University Of London

MSc in Artificial Intelligence

Project Report

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Ablation Study on Faster-RCNN for Hepatocellular Carcinoma Detection

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**Declaration**

By submitting this work, I declare that this work is entirely my own except those parts duly identified and referenced in my submission. It complies with any specified word limits and the requirements and regulations detailed in the assessment instructions and any other relevant programme and module documentation. In submitting this work I acknowledge that I have read and understood the regulations and code regarding academic misconduct, including that relating to plagiarism, as specified in the Programme Handbook. I also acknowledge that this work will be subject to a variety of checks for academic misconduct.

Signed: Benjamin Dwumah

**ABSTRACT**

Hepatocellular carcinoma (HCC) is one of the most prevalent causes of cancer incidences and deaths. Despite many years of research and the creation of new medical interventions, patients with HCC continue to have poor treatment outcomes. Patients with HCC suffer from unfulfilled concerns like risk prediction, individualised treatments, accurate prognosis and early diagnosis. In recent years, there has been a massive growth in Artificial Intelligence (AI) applications in medical research, and the field of HCC is no exception. Deep learning algorithms are among the most advanced AI-based machine learning algorithms for processing and analysing complicated multimodal data, from routine diagnostic factors to high-resolution medical images. In this research project, I present my experiment results and review for early diagnosis of HCC using deep learning techniques, specifically Computer Vision. I have done detailed experiments on the object detection model Faster Region-Based Convolutional Neural Network (Faster R-CNN) for detecting HCC. I experimented with different backbones for the Faster R-CNN model. I concluded that the backbone plays a significant role in the Faster-RCNN architecture for good accuracy results and performance. The codebase is available at: <https://github.com/Ben74x/Indiv_Proj>

**Keywords:** Hepatocellular carcinoma (HCC), Artificial intelligence, Deep learning, Computer Vision, Object Detection.

**1. Introduction**

Hepatocellular carcinoma (HCC) is an aggressive primary liver cancer that develops in the setting of chronic parenchymal liver diseases and is among the top causes of cancer incidence and mortality worldwide (Bray et al., 2018; Yang et al., 2019). While the hardship of having HCC has decreased with effective antiviral therapy, HCC cases associated with metabolic syndrome are expected to rise further due to the significant increase in the commonnes of non-alcoholic fatty liver disease (NAFLD) in the general population (Stepanova et al., 2017).

Decades of research in HCC have resulted in the development of a screening protocol, non-invasive imaging-based diagnostic modalities, and different treatment modalities, including surgical, locoregional and systemic therapies (Llovet et al., 2021; Yang and Heimbach, 2020). Nevertheless, the results of patients with HCC continue to be poor. There are areas of critical unmet demand in early detection, accurate prognostication, risk prediction, and individualized treatments.

A lot of health data is produced by HCC patients. While this is exciting for researchers, guaranteeing that such large amounts of data are converted into actionable insights can be difficult. Artificial intelligence (AI) is considered to be capable of synthesising and analysing multimodal data with extraordinary levels of accuracy, and the use of AI to several areas of medicine, including hepatology, has grown rapidly in recent years (Ahn et al., 2021). For a wide range of tasks and clinical applications, such as image classification, detection and segmentation, etc, AI-based concepts offer a variety of techniques. Recent developments in AI, specifically in the field of medical image analysis, provide a vast array of automated tools for obtaining precise measurements of biomarkers, exposing delicate features, categorising tissue characteristics, and conducting radiomics for in-depth analysis of raw imaging data. The introduction of deep learning techniques have made the AI revolution of the past ten years conceivable. This research analyses how the object detection model model, Faster R-CNN, performs in the detection of HCC lesions.

The main question for this research study is: *“Can customized Faster R-CNN models detect HCC lesions better than the base model?”*

**1.1 Objectives, Project Product, and Beneficiaries**

In this project, my goal is to research, understand, and experiment the Faster R-CNN model to see if it is appropriate for use in the detection of HCC by contrasting the base model with modified versions. The project's final product is a fully operational Faster-RCNN model that has been trained on data from liver cancer patients with HCC and can be used in real-world scenarios.

The following are the project deliverables:

* Extensive research on the Faster R-CNN model for HCC lesion detection
* Results of using the top-performing model to find HCC lesions in ultrasound scans

By incorporating the top performing algorithm in this project into their applications, researchers from many fields of study, as well as medical professionals working in the field of cancer, can gain from this project. Additionally, this project offers thorough information concerning the effectiveness of the Faster RCNN algorithm and its contributing factors to the performance of HCC detection, which can aid in future research. Furthermore, anyone with a foundation in machine learning will also gain from developing their knowledge of deep learning, particularly computer vision.

**1.2 Structure of the Project Report**

In Section 2, I discuss Artificial Intelligence and its applications in the health sector. I also detail machine learning, its types and limitations. I then discuss deep learning and give a brief overview of the computer vision and its applications in the health sector. Finally, I describe the concept of object detection and talk about the Faster R-CNN algorithm discussing all the essential parameters.

In Section 3, I discuss the method of experiments involving the data for the project, the model, other external tools and evaluation metrics.

In Section 4, my findings from the experiments are presented along with graphs, diagrams and figures.

In Section 5 and Section 6, I introduce the project results and reevaluate the research question with regard to the experiments conducted. I then discuss the results and conclude my project report.

**2. Context**

**2.1 Artificial Intelligence**

**2.1.1. Definition**

In a 2004 study, John McCarthy gave the following definition of artificial intelligence (AI), despite the fact that there have been numerous other definitions over the past few decades, "It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable" (McCarthy 2004, p. 2).

Turing, known as the "Father of Computer Science," posed the question, "Can machines think?" in this paper. From there, he proposed a test which is now popularly known as the "Turing Test". In the test, a human interrogator attempts to differentiate between a computer and a text response from a human. While this test has been heavily scrutinised since its publication, it remains an essential part of the history of AI in addition to an ongoing concept within philosophy due to its use of linguistic ideas.

In recent times, a book by Peter Novig and Stuart Russell, Artificial Intelligence: A Modern Approach has become one of the leading learning material in the study of AI. In it, they explore four potential objectives or definitions of AI, differentiating between computer systems based on their reasoning and thinking vs acting:

* Human approach:
  + Systems that think like humans
  + Systems that act like humans
* Ideal approach:
  + Systems that think rationally
  + Systems that act rationally

Comparing Alan Turing’s definition to Peter Novig and Stuart Russell own, his definition would fall under the human approach which is systems that act like humans.

In its basic form, AI can be defined as an area incoporating robust datasets and computer science to solve problems. It has the subfields of machine learning and deep learning, which are widely discussed in the context of artificial intelligence.

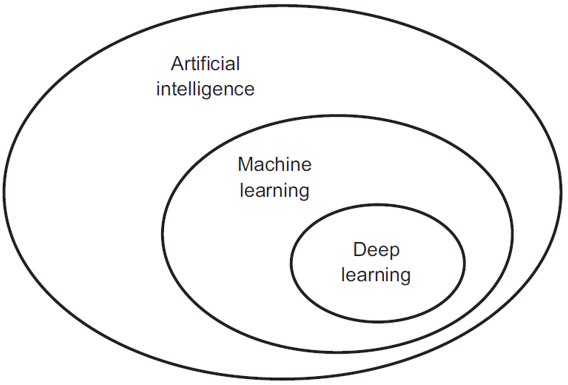


Fig. 1: Aritificial Intelligence and its subfields

AI is grouped into two types which are Weak AI and Strong AI. Weak AI, known as Narrow AI, has been trained and focused on performing specific tasks. The majority of AI applications today are driven by weak AI. The type of AI is anything but weak; it powers many applications like self-driving cars, voice assistants, personalized marketing, facial recognition systems, and gamified therapy. Stong AI comprises Artificial Super Intelligence (ASI) and Artificial General Intelligence (AGI). A computer with an intellect comparable to humans, a self-aware awareness, and the capacity to learn, reason, and make plans for the future would be said to have AGI, also known as general AI. ASI, also known as Superintelligence, would be more intelligent and capable than the human brain. Even though there are now no real-world applications for strong AI and it is only theoretical, experts in the field of artificial intelligence are continuously studying its potential.

**2.1.2. AI APPLICATIONS IN HEALTHCARE**

Healthcare delivery may change as a result of AI. It can boost output and care delivery efficiency, enabling healthcare systems to serve more people with more effective treatment. AI can assist healthcare professionals in having a better experience, permitting them to spend more time providing direct patient care and lowering burnout. One of the biggest success stories in our time is healthcare. Life expectancy has increased globally due to significant advancements in medical technology. However, as people live longer, healthcare systems must contend with expanding patient demand, rising expenditures, and a stretched-thin staff. Population ageing, shifting patient expectations, a change in lifestyle preferences, and the endless cycle of innovation are just a few of the inescapable drivers that drive demand. The effects of an ageing population stand out among these. One-fourth of the people in North America and Europe will be over 65 by 2050, which means the healthcare systems will be required to cope with more patients with complicated demands. It is expensive to manage these patients, and systems must change from a philosophy of periodical care to one that is considerably more proactive and centred on long-term patient care.

The expenditure on healthcare is growing. Healthcare systems will have difficulty staying sustainable unless significant structural and innovative changes are made. Health systems require a larger workforce as well. However, while the world economy could generate 40 million new healthcare jobs by 2030, the World Health Organization predicts a 9.9 million physician, nurse, and midwife shortage over the same time period. Not only must we attract, train, and sustain more medical professionals, but we must also ensure that their time is spent where it adds the most value, which is caring for patients. AI, which is based on automation, has the potential to revolutionise healthcare and assist in addressing some of the issues raised above. AI can improve care outcomes as well as the efficiency and effectiveness of care delivery. It can also improve healthcare practitioners' daily lives by allowing them to spend more time caring for patients, increasing staff morale and retention. It can even help bring life-saving treatment methods to market faster. Simultaneously, concerns have been expressed about the influence AI may have on patient populations, professionals, and health systems, as well as the risks involved; there are ethical debates about how AI should be used.

According to Spatharou, Hieronimus and Jenkins (2020), a growing number of governments have set forth goals for AI in healthcare, and several are making significant investments in the field. Venture capital (VC) expenditure for the top 50 companies in healthcare-related AI reached $8.5 billion, and huge tech companies, startups, pharmaceutical and medical device companies are all involved in the developing AI healthcare ecosystem.

**2.2. Machine Learning**

**2.2.1 Definition**

Machine learning is a subset of artificial intelligence. Machine learning focuses on data driven learning, whereas artificial intelligence focuses on general intelligent behaviour. Machine learning is the process by which a computer learns from data. The program takes in data, and from the data, the program learns. In the process, the program creates a model, which can then be used to make predictions about future data. The predicted values are usually, but not always, probabilistic in nature. That is, the model is a mathematical model which gives probabilities for events in the data. However, the model is only sometimes probabilistic. For example, decision trees are not probabilistic, but they are a model of the data.

A more detailed definition of machine learning would be “A computer program is said to learn from experience E with respect to some class T and performance P, if its performance at tasks in T, as measured by P, improves with experience E” (Mitchell 1997, p. 2).

Machine learning is a vast and vital field of study. The practical significance of machine learning cannot be overstated. Many of the applications we use every day are machine learning applications. Email apps, for example, use machine learning to distinguish between spam and legitimate emails. It is also used in search engines to prioritise web pages, in speech recognition applications to recognise speech, and in image recognition applications to recognise images.

**2.2.2 Types of Machine Learning**

Machine learning algorithms can solve a wide range of problems. Machine learning algorithms are currently trained using four distinguished methods: supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning.

Machine learning algorithms can be trained in a variety of ways, each with its own benefits and drawbacks, like any other method. We must first examine the types of data that each type of machine learning consumes in order to comprehend the benefits and drawbacks of each type. Labeled data and unlabeled data are the two types of data used in machine learning. Although labelled data has both the input and output parameters in a properly machine-readable form, labelling the data initially takes a significant amount of human effort. In unlabelled data, only one or none of the parameters are present in machine-readable form. This eliminates the need for human work but calls for more complex solutions. Furthermore, certain machine learning algorithms have extremely specific applications; yet, the four primary approaches are still in use today.

Supervised learning is the most prevalent kind of machine learning. In supervised learning, the algorithm analyses labelled data. In other words, the data has some marking, and for each input, the appropriate output is given to the application. Numerous applications include supervised learning. Email applications, for instance, employ supervised learning to categorise emails as spam or not. Applications for image recognition identify images using supervised learning. Applications for speech recognition classify sounds using supervised learning. Constructing a model that links inputs to outputs is the aim of supervised learning.

Learning from unlabeled data is referred to as unsupervised learning. The algorithm gathers information and makes learning from it. However, the algorithm is not informed of the proper output. The algorithm understands relationships between data points in an abstract way; human input is not necessary. Unsupervised learning methods are flexible because of the development of these hidden structures. Unsupervised learning algorithms can modify their underlying structures dynamically to respond to the data rather than using a predetermined and stated problem statement. This provides more post-deployment development than supervised learning techniques. There are numerous uses for unsupervised learning. Unsupervised learning may be used by an email application, for instance, to group spam emails.

Machine learning techniques such as semi-supervised learning allow the algorithm to learn from labelled and unlabeled input. The use of semi-supervised learning is widespread. Semi-supervised learning, for instance, might be used by an email application to categorise emails as spam or not. The algorithm may use unlabeled data to identify spam email clusters. Then, it might classify emails as spam or not using labelled data. Better models can be learned via semi-supervised learning than with supervised learning alone.

Reinforcement learning is a subset of machine learning in which the algorithm learns through "trial and error" experiments. The algorithm starts with an initial state and then acts. The algorithm is then rewarded or punished for its actions. The process is then repeated, beginning with the initial state until the algorithm has explored the space of possible actions. Reinforcement learning is used in a wide range of applications. For example, a chess programme might use reinforcement learning to teach itself how to play the game. The goal of reinforcement learning is to learn a policy that determines each state's best course of action.