

Iowa Initiative for Artificial Intelligence

Final Report

Project title:	Machine-learning based investigation of prognostic indicators for oncological outcome of pancreatic ductal adenocarcinoma		
Principal Investigator:	Carlos Chan		
Prepared by (IIAI):	Yanan Liu		
Other investigators:			
Date:	June 2022		
Were specific aims fulfilled:	YES		
Readiness for extramural proposal?	YES		
If yes ... Planned submission date	February 2023		
Funding agency	NIH		
Grant mechanism	R21		
If no ... Why not? What went wrong?			

Brief summary of accomplished results:

We have developed and validated a 3D CNN model to automatically predict the presence of lymph node metastasis and postoperative cancer-positive margin status based on preoperative CT scans. For the lymph node metastasis prediction 3D-CNN model, obtained accuracy was 90% for per-patient analysis and 75% for per-scan analysis. For the postoperative margin status prediction 3D-CNN model, achieved accuracy was 81% for per-patient analysis and 76% for per-scan analysis.

Research report:

Aims (provided by PI):

This proposal aims to utilize an artificial intelligence algorithm to predict lymph node and margin metastasis.

Data:

CT images, clinical and pathologic data were obtained from 110 patients. A total of 881 CT scans were obtained.

AI/ML Approach:

A 3D CNN model [1] was implemented for image classification – each image was classified as positive or negative based on its lymph node and margin metastasis presence. Due to small numbers of patients, each CT scan was treated as independent. The training vs. validation split was 59 patients (340 scans) vs. 20 patients (140 scans) for the lymph node study and 83 patients (629 scans) vs. 27 patients (252 scans) for the margin-status study.

Experimental methods, validation approach:

Data Preparation

In order to use CT image efficiently, specific CT slices were selected reflecting the presence of lymph node/margin tissue.

Data preparation or pre-processing is an essential step in any machine learning study. In order to save computation time, we resized each image to the size of 128x128x64. In this project, data normalization is an important step which ensures that each input parameter (voxel) has a similar data distribution. This makes convergence faster while training the model. We normalized the image intensity to [0,1].

Image Classification

The 3D CNN is one of the most popular machine learning models for image classification. 3D convolutional neural network architecture, which consists of several modules of 3D conv, maxpool and batch normalization layers, was selected for this task. Its basic architecture is shown in Fig. 1.

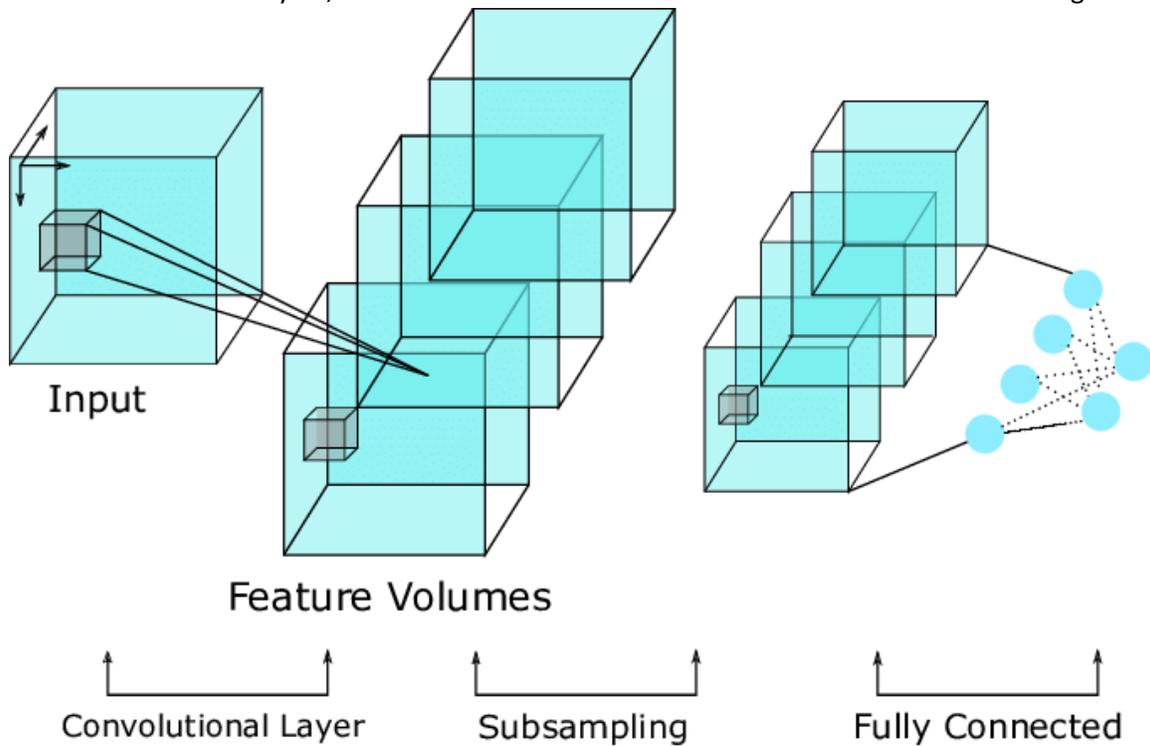


Figure 1. 3D CNN basic architecture [2].

Results:

For the lymph node prediction 3D-CNN model, accuracy was 90% for per-patient analysis and 75% for per-scan analysis. For the postoperative margin-status prediction 3D-CNN model, accuracy was 81% for per-patient analysis and 76% for per-scan analysis.

Since we only had 110 patients, the accuracy can likely be further improved once/if more data become available.

Ideas/aims for future extramural project:

Given a positive outcome of this study, we plan to apply for funding to further train our 3D-CNN model with a larger cohort and to enroll patients prospectively in a clinical trial setting for predicting post-surgical pathological outcome and for determining treatment sequencing (i.e. upfront surgery vs. neoadjuvant therapy for “resectable” pancreatic cancer). We will apply for R21 aiming for the Clinical Oncology Study Section.

Publications resulting from project:

A manuscript has been submitted to the Frontier in Oncology journal. It has been reviewed and a revision was requested.

Jeremy Chang, Yanan Liu, Stephanie Saey, Kevin Chang, Hannah Shrader, Kelsey L. Steckly, Maheen Rajput, Milan Sonka, Carlos H.F. Chan, Machine-learning based investigation of prognostic indicators for oncological outcome of pancreatic ductal adenocarcinoma, Frontier in Oncology

Reference:

1. Hasib Zunair, Aimon Rahman, Nabeel Mohammed, and Joseph Paul Cohen, Uniformizing Techniques to Process CT scans with 3D CNNs for Tuberculosis Prediction, arXiv:2007.13224
2. Roy, Aprameyo, and Mishra, Deepak, ECNN: Activity Recognition Using Ensembled Convolutional Neural Networks, 2019/02/06, DOI - 10.13140/RG.2.2.13080.44808