Iowa Initiative for Artificial Intelligence

Final Report

Project title:	Predicting Dysplastic Hip Survivorship after Periacetabular Osteotomy Based on Discrete Element Analysis-Derived Contact Stress Patterns
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Date:	

Were specific aims fulfilled:	Y
Readiness for extramural proposal?	N
If yes … Planned submission date	
Funding agency	
Grant mechanism	
If no … Why not? What went wrong?	The result is not sufficiently good due to small dataset size and sparsity of data.

Brief summary of accomplished results:

We have developed and validated machine learning models to predict survivorship of failure of dysplastic hip using 4D information contained in stress map. For original image input, CNN was used and the best accuracy is 0.56. For PCA features extracted from original image, Random Forest was used and the best accuracy is 0.54.

Research report:

Aims (provided by PI):

The aim of this project is to develop an AI-based approach to identify contact stress patterns that predict survivorship or failure of dysplastic hips from the full 4D information contained in DEA-based contact stress maps.

Data:

We got one of the largest long-term follow-up studies of young-adult patients with hip dysplasia treated with periacetabular osteotomy (PAO). We mapped contact stress using discrete element analysis (DEA) on the symptomatic hips of these patients. The data consists of a set of 3D contact stress maps computed for 13 discrete timepoints spanning the stance phase of walking gait. Each patient has both a preoperative and postoperative (after PAO) contact stress data set and an assessment of whether their hip is considered clinically preserved or failed 10+ years after PAO (based on a combination of patient reported outcomes and history of conversion to total hip arthroplasty).

AI/ML Approach:

CNN

A Convolutional Neural Network (CNN) is a specialized deep learning model designed to process grid-like data such as images. A CNN model works by passing an input image through a series of specialized layers to extract features and make predictions.

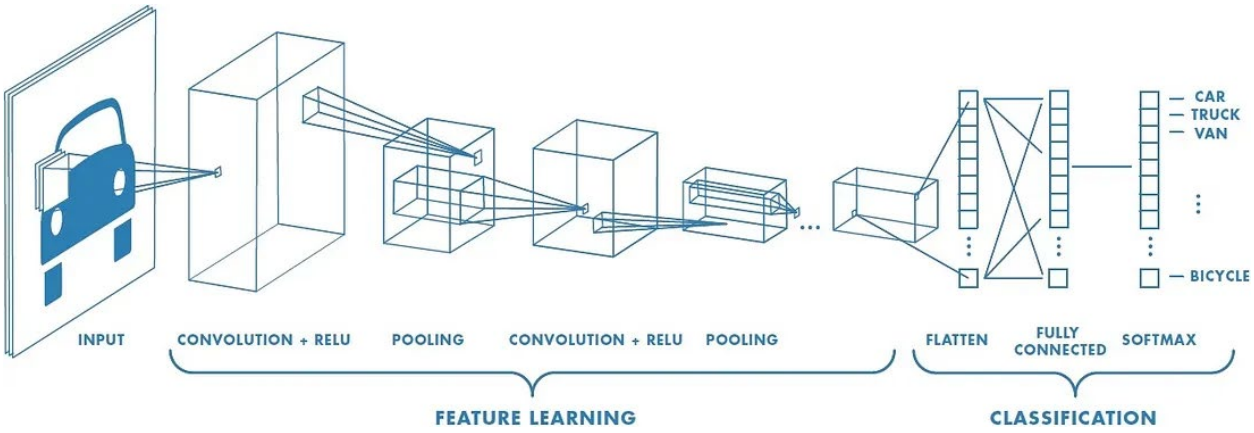


Figure 1. Representation of CNN model

Random Forest

In this study, supervised machine learning algorithm was implemented for prediction using Python. As many extracted features may be noisy, or highly correlated with each other, Random Forest (RF) algorithm was selected to predict success/failure group. A random forest classifier constructs multiple decision trees using a random subset of data. Each tree makes a prediction, and the final output is determined by integrating the individual predictions. Random forest also helps reduce overfitting and can provide feature importance rankings.

To help boost the model's performance on a small dataset, K-Fold Cross Validation was used. This technique divides the dataset into k subsets or folds. The goal is to make sure every data point gets a chance to be in both the training and testing sets. On the first iteration the model is trained in k-1 folds and then tested on the remaining fold. On the second iteration a different fold is used for testing, and the process is repeated for the k number of iterations. This method helps estimate the model's performance on a limited data set.

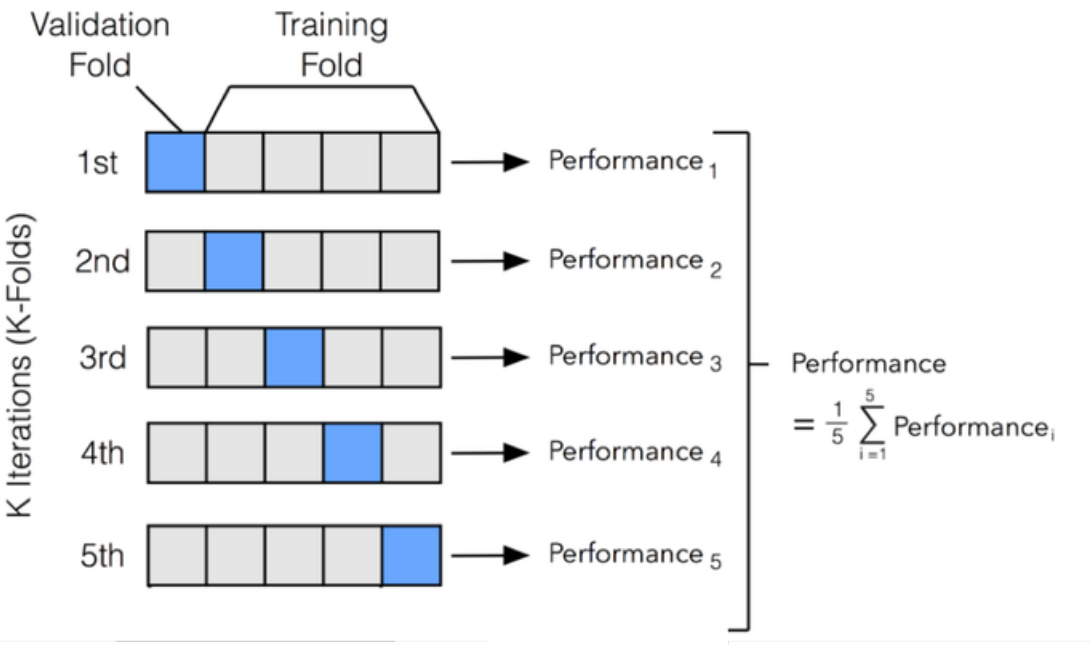


Figure 2. Representation of 5-fold cross-validation technique

Results:

The accuracy is 56% using CNN model and 54% using RF model due to small dataset and sparse data.