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Abstract

This project builds a convolutional neural network model to take the standard three x-ray views of the wrist taken for a suspected distal radius fracture, PA view, oblique view, and lateral view, in DICOM format and classify the fracture as Type I, Type II, or Type III according the Orbay-Mercer system.

System Administration guide for distal radius fracture Project

A Convolutional Neural Network Model for Image Classification

System Administration Guide for Distal Radius Fracture Project

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**System Administration for Distal Radius Fracture Classifier**

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# **Legal Notice**

The work for this classifier was done in partial fulfillment of a Master of Science degree in Data Science at Grand Canyon University. All the data used for training and validation of the convolutional neural network (CNN) was obtained from the University of New Mexico (UNM) Health Sciences Center (HSC) picture archiving and communication system (PACS). Classifications provided by this system are meant to be used as one input for treatment decisions. No warranty or guarantee of the accuracy of the classification is made or implied.

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# **General Information**

Orthopaedic surgeons at the University of New Mexico Health Sciences Center (UNM HSC) have developed a new classification system for distal radius fractures based on the stability of the distal radio-ulnar joint (DRUJ). This is clinically significant because instability of the DRUJ means that the wrist may need to be immobilized and early rotation of the affected arm will not be possible. A convolutional neural network (CNN) machine learning model was built to use plain x-rays of three views of the fracture to classify the fracture. The three views are posterior-anterior (PA) view, oblique view, and lateral view. The model was trained and validated using 300 cases from the UNM HSC PACS. An additional 50 cases were used to test the system. The most successful model parameters were saved and a classifier was built using Python.

The classification system is described below.

Type I: The triangular fibrocartilage complex (TFCC) and the distal portion of the interosseous forearm ligament or distal interosseous ligament (DIOL) remain intact after the distal radius fracture (DRF). There is no residual instability or subluxation of the distal radio-ulnar joint (DRUJ) after anatomical reduction of the skeletal structures. This is the injury found in minimally displaced DRF’s and in fractures of both radius and ulna which occur just proximal to the DIOL. They need no specific treatment besides restoration of the bony anatomy.

Type II: The TFCC and the extensor carpi ulnaris (ECU) tendon sheath rupture but the DIOL remains intact. DRUJ subluxation is corrected and adequate stability is restored after anatomical reduction of the skeletal structures. The distal ulna and/or the ulnar styloid may or may not be fractured. This is the concomitant DRUJ injury found in most displaced DRF’s.

Type III: The TFCC, the ECU tendon sheath and the DIOL all rupture. Therefore, all ligamentous support for the DRUJ is lost. After anatomical reduction of the skeletal structures, either subluxation of the DRUJ persists or clinical testing shows DRUJ instability. It is necessary to address the persisting DRUJ instability by specific means and early forearm rotation is usually not possible. This is the concomitant DRUJ injury found in the Galeazzi fracture, fractures of the distal radius with radio-ulnar diastasis and some high energy comminuted distal radius and ulna fractures (Mercer et al., 2021).

Table 1. Classification System

|  |  |  |
| --- | --- | --- |
| Intact/Not Intact +/- | TFCC/ECU | DIOL |
| Type I | + | + |
| Type II | – | + |
| Type III | – | – |

# **System Overview**

The project was written in Python 3.8 using Anaconda. The data preparation and Convolutional Neural Network model were done using Jupyter notebooks. The classifier is run from a Python script file in the Spyder environment. Table 2 shows the components of the system.

Table 2. Components of project

|  |  |  |
| --- | --- | --- |
| **Component** | **Name of file** | **Dependencies** |
| Data Preparation – Read DICOM images, crop and convert to CSV | CropImages.ipynb | Required packages: numpy, pandas, PySimpleGUI, pydicom, matplotlib |
| Data Preparation – Group images for training/validation set and testing set | DataPrepforDRUJ  TrainVal.ipynb  DataPrepforDRUJTest.ipynb | Required packages: numpy, pandas, matplotlib |
| Convolutional Neural Network Model builder | CNNforDRUJCombinedView  ReducedResolution.ipynb | Required packages: numpy, pandas, matplotlib,  random, tensorflow, keras, sklearn |
| Classifier | DRUJClassifier.py | Required packages: numpy, pandas, PySimpleGUI, matplotlib, keras, |

# **System Configuration**

The Convolutional Neural Network (CNN) will run on Google Colab using a High-RAM run time. The CNN will run on a Dell Precision 7750 which has 64 Gb of RAM. The CNN will not run on most laptops. The classifier will run on most computers that have Python installed. The classifier runs in the Spyder environment. When the files are downloaded from the Google drive, all of the files should be placed in the Classifier folder.

To install Python go to this page: <https://www.python.org/downloads/>

To install Anaconda go to this page: <https://docs.anaconda.com/anaconda/install/index.html>

To install the required packages use !pip install *packageName* in the Jupyter notebook or pip install *packageName* from the command line. See tutorial here: <https://packaging.python.org/en/latest/tutorials/installing-packages/>

Download files for this project from Github using the link below and from Google drive by copying and pasting the link into your browser:

Github: <https://github.com/IHGCU/CapstoneProject>

Google drive: <https://drive.google.com/drive/folders/1V7oJKbPplCAy19pMG7dlDXWhKDYokXhN?usp=sharing>

Table 3 lists the files needed to run the CNN. Table 4 lists the files needed to run the classifier.

Table 3. Files needed to run the Convolutional Neural Network.

|  |  |
| --- | --- |
| File | Description |
| CNNforDRUJCombinedViewReducedResolution.ipynp | A Jupyter notebook that trains the model |
| ComboReduceAugTrainVal.csv | CSV file with the reduced images for the 281 training/validation cases |
| DRUJLabelsAugTrainVal.csv | The one-hot encoded labels for the 281 training/validation cases |
| ComboReduceAugTest.csv | CSV file with the reduced images for the 30 test cases |
| DRUJLabelsAugTest.csv | The one-hot encoded labels for the 30 test cases |

Table 4. Files to run classifier

|  |  |
| --- | --- |
| File | Description |
| DRUJClassifier.py | A Python script file that runs the classifier |
| model.json | A file containing the model parameters |
| model.h5 | A file containing the model weights |
| TestCases | A folder containing 5 test cases with 3 images in DICOM format each |
| TypeI.png | An image file with a typical type I fracture |
| TypeII.png | An image file with a typical type II fracture |
| TypeIII.png | An image file with a typical type III fracture |

# **System Maintenance**

The system should not need maintenance beyond keeping the installed versions of Python and the packages up to date. We hope to enlarge the training set in the future. If and when that happens, we will update any users with the added information. We are hoping to recruit several institutions to contribute additional images to this study.

# **Security Considerations**

This project involves human subject research and must meet all the requirements for such research. For that reason, this project is stand-alone and is not web-based. Any images or data that are shared have been de-identified. Anyone using the system will be responsible for maintaining HIPAA compliance.