Pediatric bone age prediction using hand radiography-a deep learning approach

The application of machine learning in healthcare is ever increasing. The use of machine learning to detect lesions from radiographic images, such as MRI, CT scan, and X-ray, is growing. Bone age is an indicator of a child's skeletal maturity. A child's bone age may or may not exactly match with the child's age according to his or her birth date. Many factors, such as nutrition, genetics, hormones, and disease states, influence the development of the skeletal [1]. The bone age study can tell how fast or slowly a child's skeleton is maturing [2] and it can also provide useful information on many other clinical concerns. Current solutions available to predict bone age are either manual and time-consuming or performance highly depends on the quality of the images. Researchers have started predicting the bone age using the deep learning model.

Data

A deep learning model was trained using the data set provided in the Pediatric Bone Age Challenge (2017) organized by the Radiological Society of North America (RSNA). The data set can be found here.

The data set includes 12,611 hand radiographs (X-ray) for training; 1,425 hand radiographs for validation; and 200 hand radiographs for testing. The data set also includes three CSV files, one for each training, validation, and test data, and contains image number along with skeletal age and sex. The skeletal age was obtained from the accompanying clinical radiology report provided at the time of imaging.

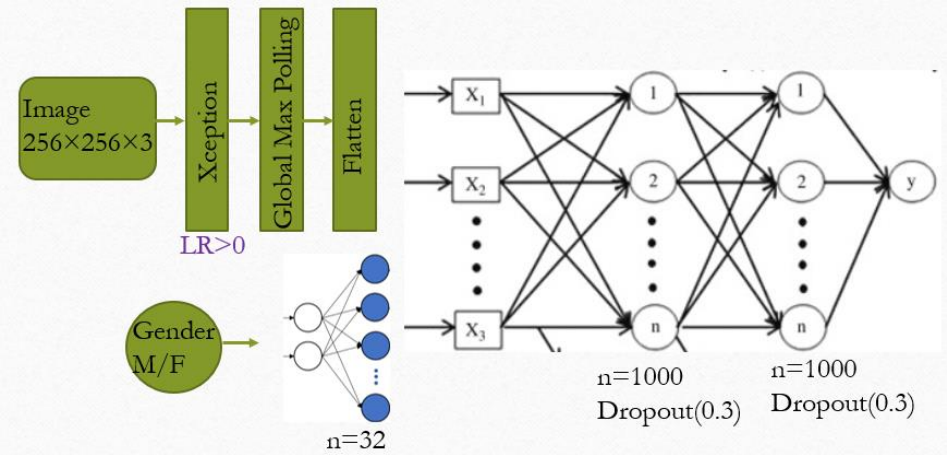
The images come with a variety of backgrounds, with different intensities, borders, angles, shapes, multiple backgrounds. The size of the image is ranging from a few hundred pixels to a few thousand pixels. Therefore, images were preprocessed to clean the background and make all images square and of the same size.

Model Inputs

- Child's hand radiography
- Child's gender information

Model Architecture

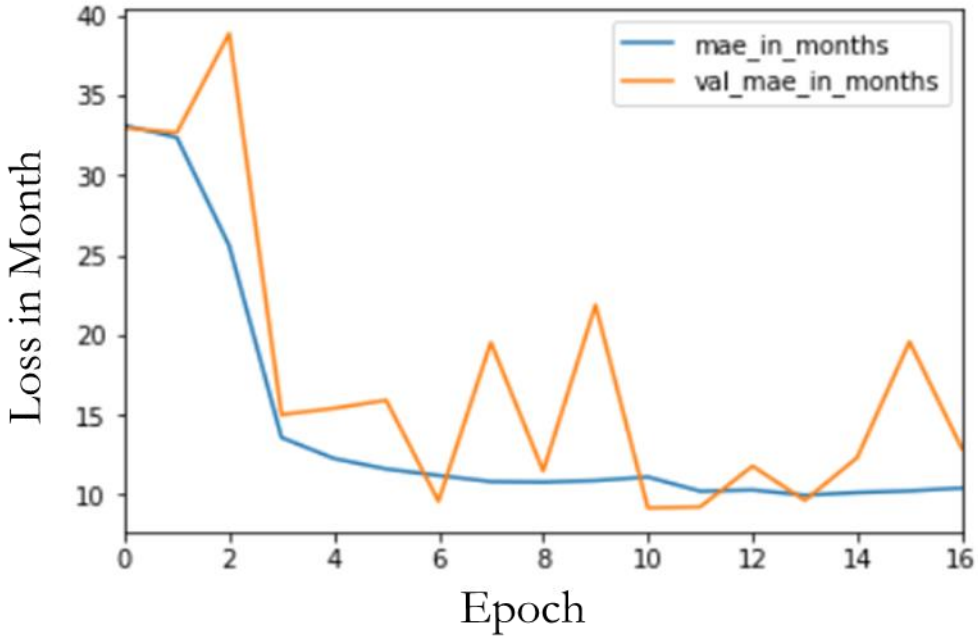
A deep learning model is constructed using a pretrained model Xception and fully connected layers as shown below.



The input images were augmented before feeding to the model. The model architecture has a single output: predicted bone age in month.

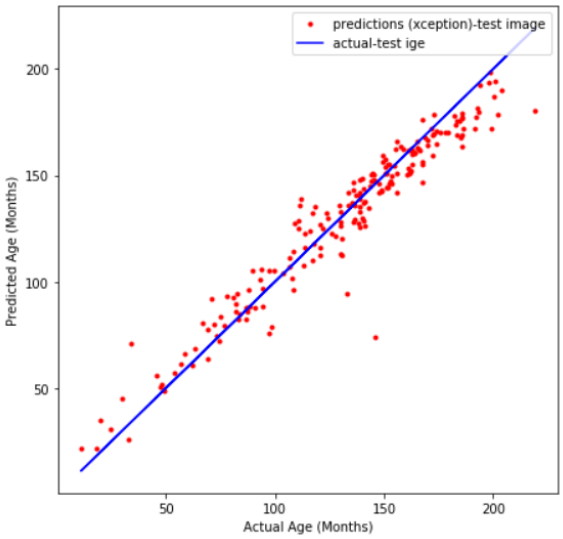
Model Training

Model was trained with 'mse' loss and 'EarlyStopping', 'ModelCheckpoint', 'ReducedLROnPlateau' callback function for 20 epochs. The training and validation loss vs number of epochs is presented below



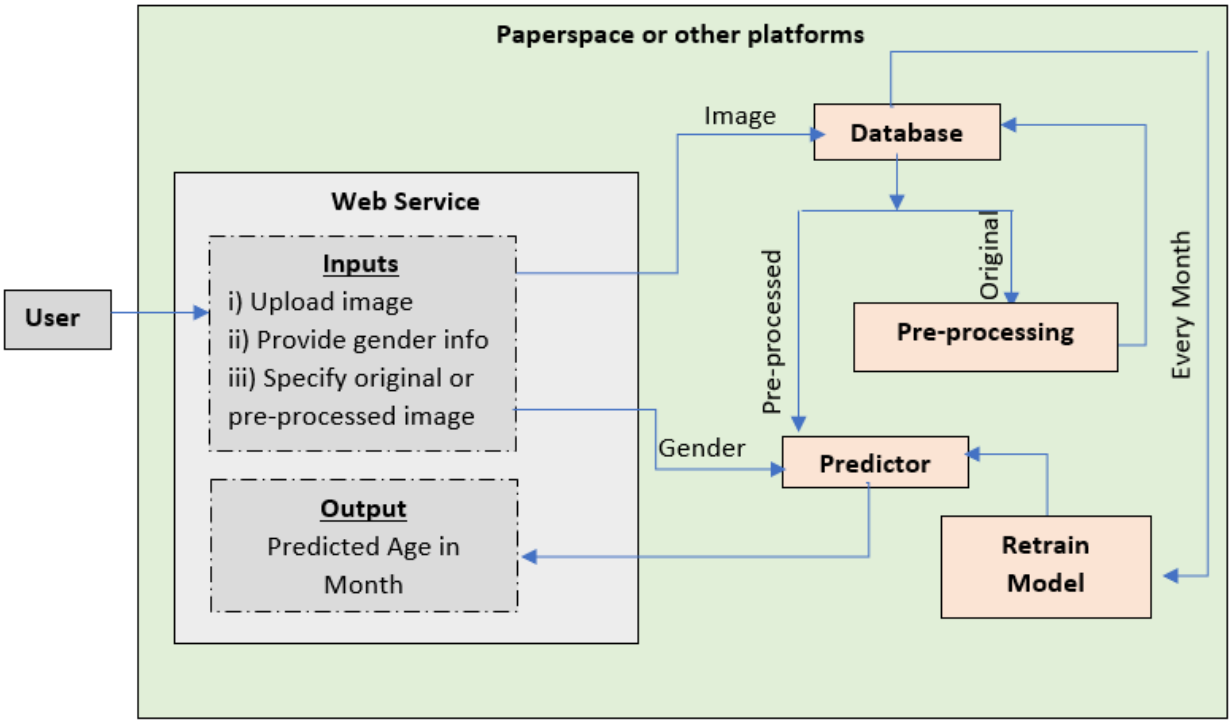
Model Evaluation on Test Data

Mean absolute distance (MAE) of the test images is 8.2 months.



Deployment Architecture

Model is deployed in the Paperspace platform using Flask API. Deployment architecture is as shown below.



Conclusion

The preliminary result of the application of a deep learning model for bone age prediction is promising. This work demonstrated that the deep learning approach might be very successful to predict a child's bone age. Deep learning models are very successful in many applications such as self-driving cars and facial recognition. The deep learning model has great potential in the health care application, and it can become a physician aide for early detection of the disease and monitoring treatment plans.