Artificial Intelligence in Radiology Across Four Modalities

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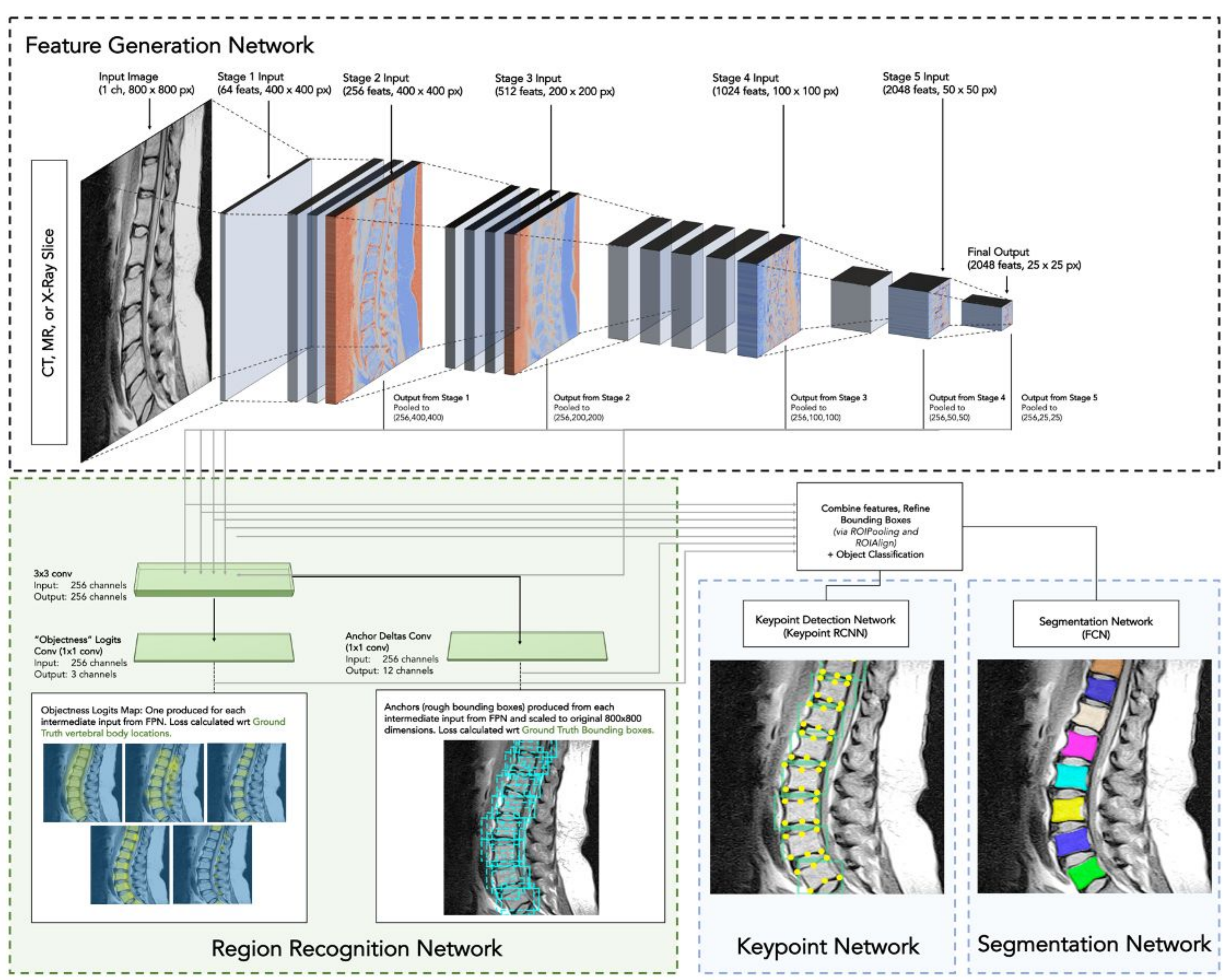
Purpose

Vertebral fractures comprise almost 50% of osteoporotic fractures in the United States. Vertebral deformity fractures can be classified as wedge, biconcave, or crush, depending on the anterior (Ha), middle (Hm), and posterior (Hp) heights of each vertebral body. However, determining these measurements is time-consuming and resource intensive. Artificial Intelligence algorithms offer the ability to automatically determine Ha, Hm, and Hp and segment vertebral bodies for 3D bone quality assessment. We report the development and testing of a deep learning neural network implementation for analyzing sagittal spine CT and MR images.

Methods

Sagittal spine MR (T1) and CT scans (MR = 998 subjects, age 67 ± 11yrs; CT = 35 subjects, age 64 ± 3yrs; all female) were used to train two networks (Fig.1 under "Results" section). A key-point detection network was trained with 4622 labeled vertebral bodies--augmented to 5667 vertebrae (4398 MR, 1269 CT)--to find relevant points for height calculations. A 3D segmentation network was trained with labelled scans (68 MR, 35 CT) to extract volumes of vertebral bodies and discs. Accuracy of the neural networks were measured using two parameters: 2D/3D Dice score (ranges from 0 to 1 where 1 means predicted segmentation = labelled ground truth) and error distance (distance of predicted key-point location to true location). Each network was evaluated with 238 MR and 15 CT scans.



Results

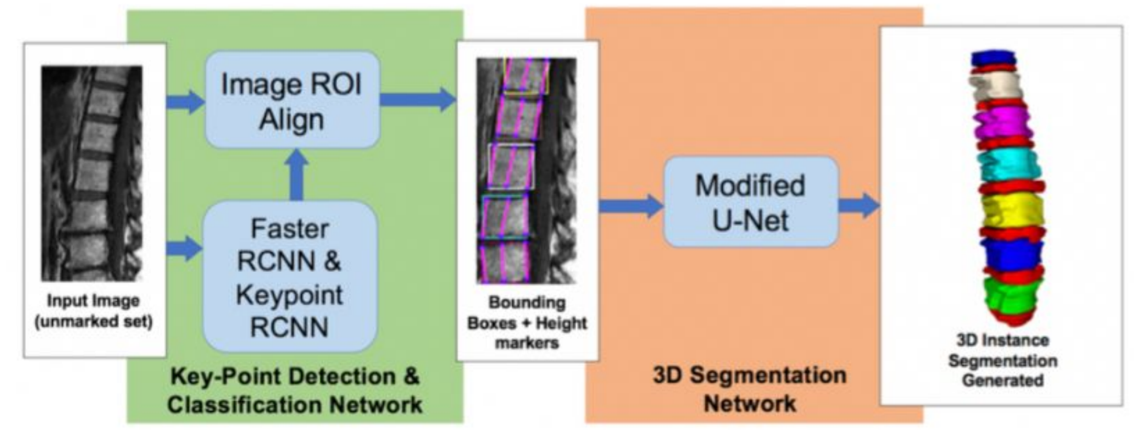


Figure 1: Basic overview of the Neural Network layout. Picture shown for MRI series. Different colors in 3D instance segmentation represent distinct vertebral body volume outputs from algorithm. RCNN stands for recurrent convolutional neural network. A U-Net is a type of CNN (convolutional neural network).

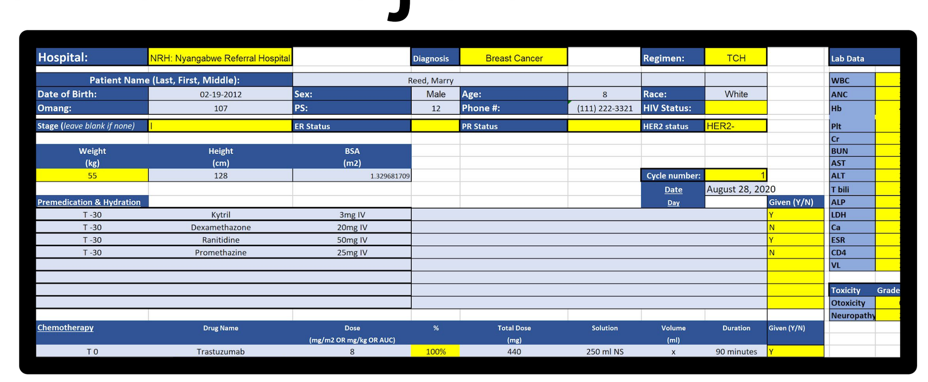
Metric	MR	CT
2D DICE Coefficient (0 to 1; 1 = best)	0.98	0.96
3D DICE Coefficient Vertebral Bodies (0 to 1; 1 = best)	0.93	0.96
3D DICE Coefficient Vertebral Discs (0 to 1; 1 = best)	0.92	-
Mean Distance (mm; lower = better)	0.69	1.28
Mean % error in Height calculations	0.09%	0.17%

Table 1: Performance statistics of neural network on MR and CT. Vertebral discs not visible in CT scans, hence no 3D Dice Score for that value.

Conclusion

The neural network was able to determine morphometric measurements for detecting spinal deformities with high accuracy on sagittal MR and CT images. Additionally, it was able to extract 3D volumes for vertebral bodies and discs. Thus we were able to show AI algorithms are able to automatically extract measurements for rapid quantification of vertebral bone health. This approach could simplify the screening, detection of changes, and surgical planning in patients with vertebral deformities and fractures by reducing the burden on radiologists who have to do these measurements manually.

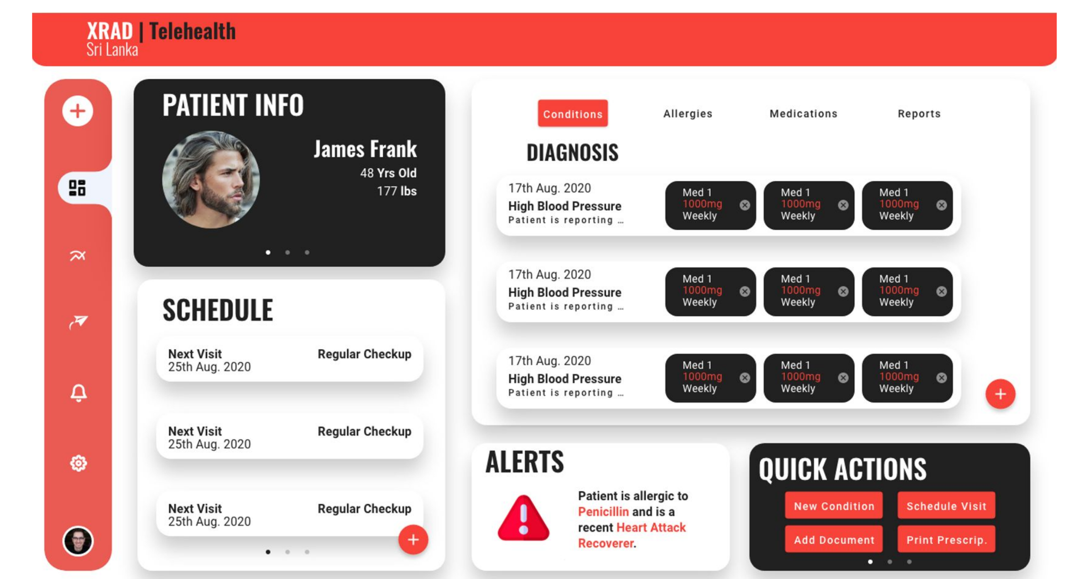
Botswana Project



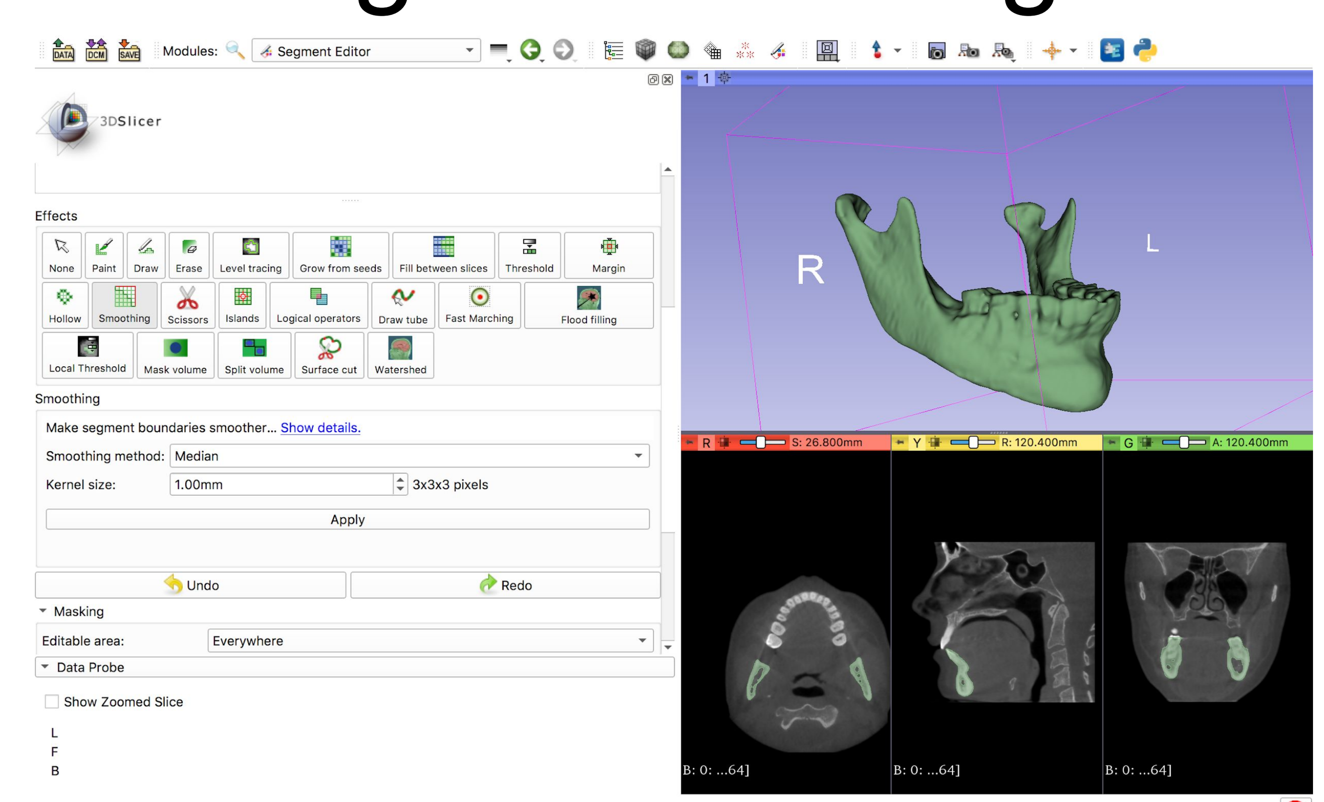
Another project was worked on in collaboration with oncologist Dr. Yehoda Martei. We designed a database that could be used in select cancer clinics within Botswana. The database acts as a query to receive and store patient information. Also, given certain parameters, it is also a clinical aid that provides medications, doses, and suggestions for treatments automatically after patient entry. The database was designed within Excel to avoid the need for WIFI. It is currently being tested within some clinics. Future modifications can be added to the database given the necessities of each clinic.

Light-Weight Electronic Medical Records System for Small Hospitals

Another developing project is xRAD. xRAD is a cloud-based electronic medical records system (EMRS) platform that aims to empower physicians of developing nations in providing online access to patient data and communication. The EMRS can handle basic patient information, serving as a patient chart for documentation, viewing of scans, and sending out prescription orders. xRAD will also help hospitals determine statistics and analytics of their patient population. After stress testing, the EMRS is projected to pilot in rural hospitals in the Philippines by October 2020.



AI for Surgical Planning



The Head CT project is still ongoing. The project seeks to develop a convolutional neural network to reduce the planning time for oral and maxillofacial surgery. Using DICOM series of head CT scans, we created a 3D model of the mandible within the Slicer application. The mandible would be digitally isolated by erasing portions of the upper teeth, the cervical spine, and a majority of the skull. The 3D model would then be smoothed, masked, and stored in a central database to await further analysis.