Automated Spinal Segmentation and Remote Sensor Calibration

Computer Integrated Surgery II
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Damiano Marsili, Arijit Nukala, Jonathan Young under Evan Haas and Antony Fuleihan

Introduction

- Our team developed a cloud pipeline to automate the process of calibrating sensors placed on a spine. To do this, our team first developed a spinal segmentation model of the spine and identified key points along the spine utilizing computer vision. A transfer function then calibrates the spinal key points against the sensor data. Lastly, a cloud system is developed for patients to upload their data and process their data for doctors.
- This pipeline is designed to calibrate these sensors so that doctors have a better sense of how the spine behaves.

The Problem

- Currently, a substantial percentage of patients undergo revisions or have complications after spinal surgeries. In the United States alone, 1.62 million instrumented spinal fusion procedures annually [1] with complication rates being 50% [2] and revision rates 36% [2]
- Part of the reason this occurs is because doctors only have a static understanding of the behavior of the spine, not a dynamical one. This can lead to inaccurate surgical assessments. There are no current solutions to obtain dynamical models of the spine.
- Solution could reduce revision rates, while giving doctors a better understanding of patient's spines.

[1] Zhang, Y. et al. Therapeutics for enhancement of spinal fusion: A mini review. J. Orthop. Translate. 31, 73–79

[2] (2021).Rajaee, S. S., Kanim, L. E. A. & Bae, H. W. National trends in revision spinal fusion in the USA. Bone Jt. J. 96-B, 807–816 (2014).

The Solution

- One mentor's approach of addressing this issue is through placing sensors on the spine and obtaining sensor data over the course of 48 hours. However, this requires calibration of the sensors.
- Calibration process contains three components exemplified below:
  - A spinal keypoint estimation model. *Figure I*
  - A transfer function that maps between the sensor data and the spinal keypoints.
  - A pipeline that enables users to upload their data and entrust the system to utilize the spinal keypoint estimation model and transfer function to correctly calibrate their data. *Figure II*

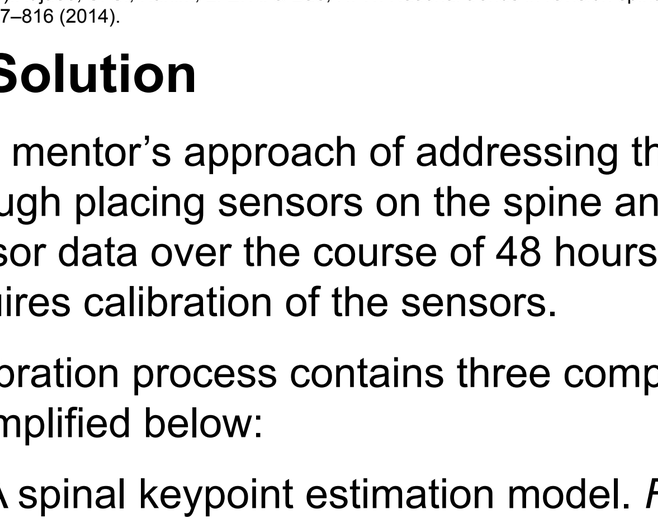

Figure I - Keypoint Estimation Model Loss Curve

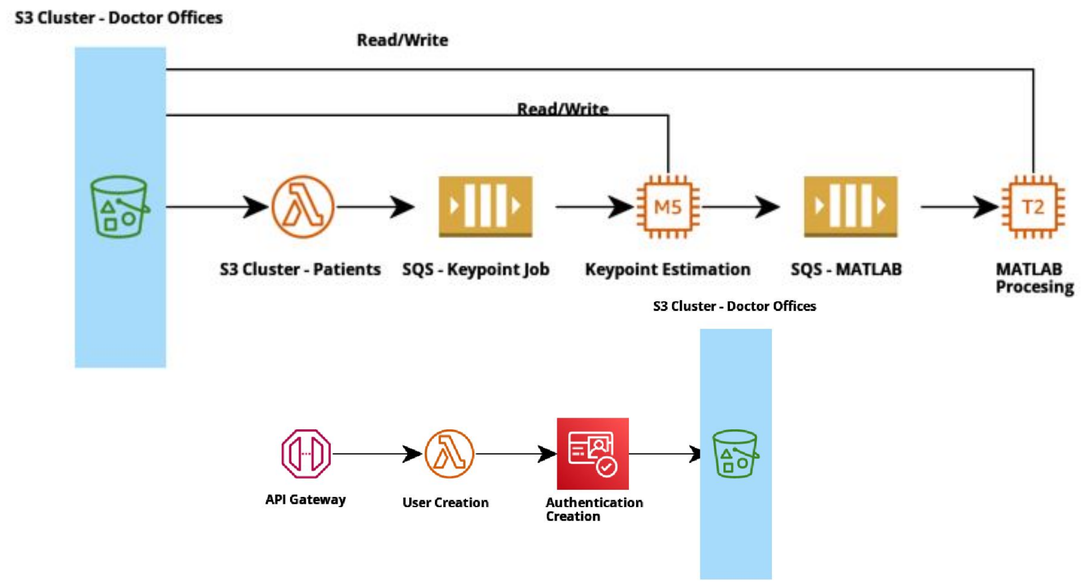

Figure II - Cloud Pipeline Flowchart

Outcomes and Results

- Our team created a key point estimation model that provide strong results given the data provided.
- Created a transfer function that calculates the spinal range of motion from IMU and model data
- Our team created a pipeline that was reliable and secure for patients to upload their data. Pipeline was able to dynamically handle an influx of data. *See Figure III*

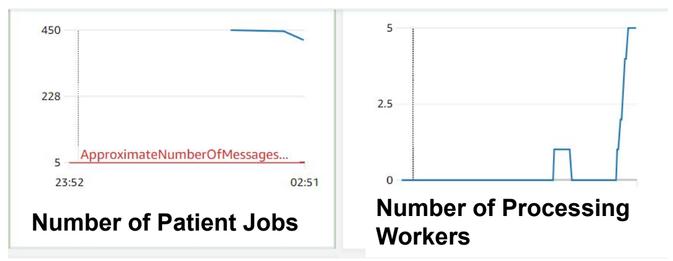

Figure III - Cloud Pipeline Handling

- Tested the pipeline through sample patient validation data.

Future Work

- Jonathan Young will be continuing on the CurveAssure team for cloud development.
- Moving forward, acquisition of patient data must be expanded to produce a better model.
- Transfer function needs to be further improved for optimization

Lessons Learned

- To create a more accurate model, the more sample data and variety of data, the better.
- Code and cloud architecture needs to be as generalized as possible due to the diversity of patient data.

Credits

- Damiano Marsili - Spinal Keypoint Estimation Model
- Arijit Nukala - Transfer Function
- Jonathan Young - Cloud Pipeline and Transfer Function

Support by and Acknowledgements

- Thank you to the CurveAssure team for guiding us through this process in creating a system that best addresses patient needs in this surgical application.

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