Robust Digitization of Perioperative Surgical Flowsheets From Low and Middle Income Countries

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Project Team



Charbel Marche



Matthew Beck



Hannah Valenty

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Background

Purpose

• Enhance a software package to extract data from paper charts

- Store in database to facilitate improvements in care
- Python Package = *ChartExtractor*
- Phone Application = EQUAL Anesthesia



Motivation

- Low and Middle Income Countries (LMICs) use paper charts
- Paper charts limit data availability
- Lack of quality improvement & real-time insights hinder developments in care
 - Contributes to worse surgical outcomes in LMICs

Sponsors



UVA Anesthesiology Department & Funded by the Center for

Global Inquiry and Innovation

Stakeholders











Previous Work

- Standardized anesthesia flowsheet was created
- Only linear transformations used for chart reformatting
- Single digit detections prevented proper vitals extraction
- YOLO detection models were good yet large & slow

Data

Data

Month Year 20 Mour (2 Patient Name

Patient Profile

 Prior Conditions

 Smoking/Vaping
 Tuberculosis
 Arthythmia

 Alcohol
 Difficult Airway
 Heart Failure

Indication for Surgery

Surgical Approach Open

Postoperative Evaluation

prature

Current Medications Aspirin Anticongulant ACE/ARB Beta Blocker

Absent Patient age >55 yrs old

Urgency
Elective
Urgent
Urgent
Emergent
Emergent
Minor
Intermediate

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Allergy

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Assumptions & Limitations

- Assumption: Data Quality
- Limitation: Data Quantity



Contributions

Contributions

- Meaning extracted from vital sign chart
- Lightweight, faster, and more accurate object detection models
- Robust image registration techniques

Determining Heart Rate and Blood Pressure

The Problem:

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Bounding boxes YOLO object detection model gives are individual digits

Determining Heart Rate and Blood Pressure

The Solution:

- Use maximum density to dynamically separate X and Y axes
- Group digits using various clustering methods



Performance of Heart Rate and Blood Pressure Determination

Clustering Method	W/O Erroneous	Bounding Boxes	W/ Erroneous Bounding Boxes						
	Time Axis mAP	Number Axis mAP	Time Axis mAP	Number Axis mAP					
K-Means	1.0	1.0	0.77	0.99					
DBScan	1.0	1.0	0.81	0.99					
Agglomerative	1.0	1.0	0.79	0.99					

Mean Average Precision 50-95 (mAP) with and without introducing 2.5% bounding boxes randomly on the axis and removing 2.5% correct bounding boxes from axis

The Problem:

- Memory-intensive YOLO object detection models are expensive to host and run on the cloud
 - Can't embed models in EQUAL Anesthesia App
 - Mobile app requires internet connection to do object detection
- Larger object detection models are slow

Previous size and runtime:

- 220MB
- 131 seconds

The Solution:

 Trained and hyperparameter tuned 7 YOLO (nano) models -- the smallest available -- on Rivanna Computing Cluster



Research Computing

The Performance:

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Improved or didn't change object detection accuracy



Change in performance before retraining and after. Precision was 1 across the board.



Change in performance before retraining and after.

Retraining Object Detection Models Performance

Detection Model	MAP 50-95		Precision		Recall				
	Before	After	Before	After	Before	After			
Digit Detection	0.83	0.84	0.94	0.94	0.79	0.79			
Intraoperative landmark detection	N/A	0.97	N/A	0.98	N/A	0.99			
Pre/Postoperative landmark detection	N/A	0.99	N/A	0.96	N/A	0.99			

Change in performance before retraining and after. Green symbolizes performance improvement. Gray is no improvement or worsening. New landmarks were included for both pre/post and intraoperative sheets so accuracy comparison could not be completed.



Transforming Images with Non-Linear Registration

The Problem: User images are not ideal





Transforming Images with Non-Linear Registration

The Solution: Coherent Point Drift, a registration algorithm





Non-Linear Registration Performance

The Performance: CPD is not generalizable yet

Lays framework for further registration





Improving Image Registration with Thin Plate Splines

The Problem:

- Operational use of the system will encounter imperfect flowsheet images
 - Folded flowsheets result in distorted images
- Distorted images make object detection difficult

The Solution:

 Deploy Thin Plate Splines (TPS) to warp distorted images to align with an ideal flowsheet

Thin Plate Splines Performance

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TPS Technique	Memory Increment (RAM)	Runtime			
No Image Size Reduction	753 MB	3.6 seconds			
0.5x Image Size Reduction	187 MB	1.1 seconds			

Conclusion

Summary

Contributions

- Facilitate extraction of semantic meaning from intraoperative vital sign chart
- O Detection model size reductions
- Augmented image registration techniques

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Thank You!

Any Questions?

