



Automated Suturing Skill Assessment in Robot-assisted Surgery from Endoscopic Videos using Clinically-guided Evaluation Criteria

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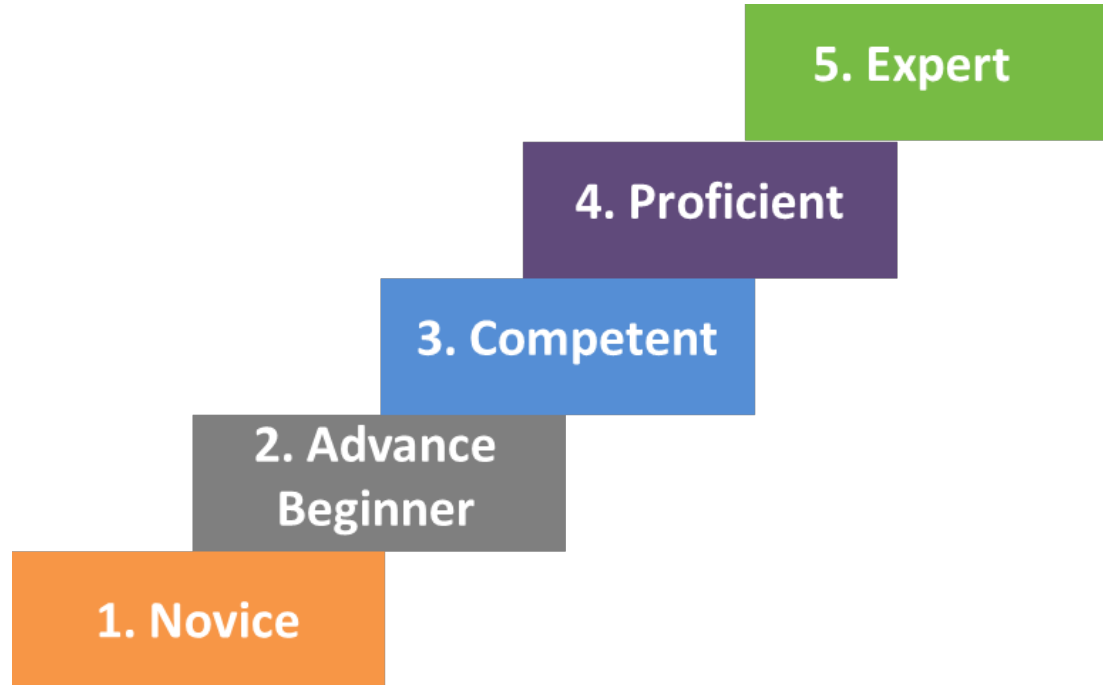
Content Warning : Surgical Imagery, Blood

1 Automated **Suturing Skill Assessment** in
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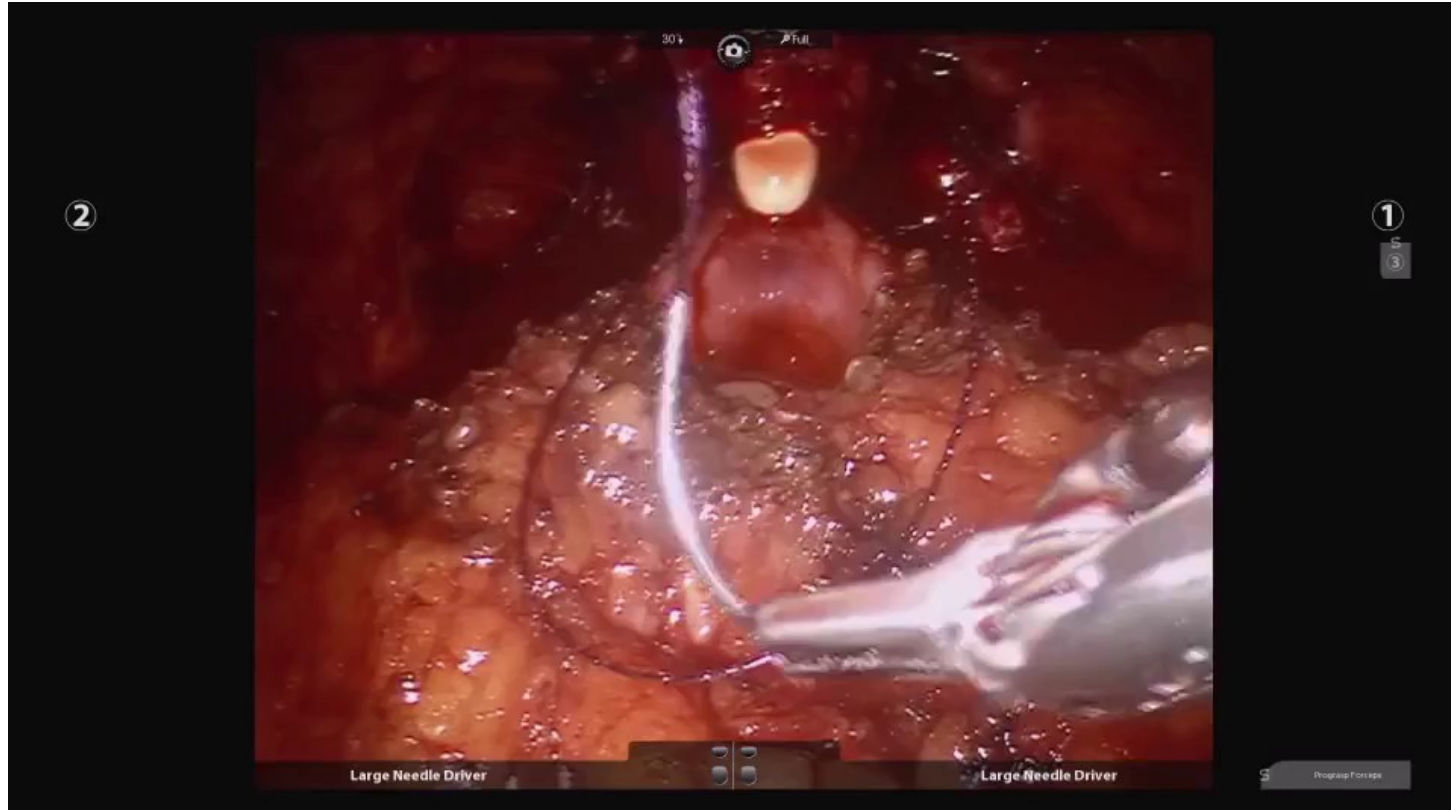
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2 Robot-assisted Surgery from Endoscopic Videos
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Dreyfus Model of Skill Acquisition

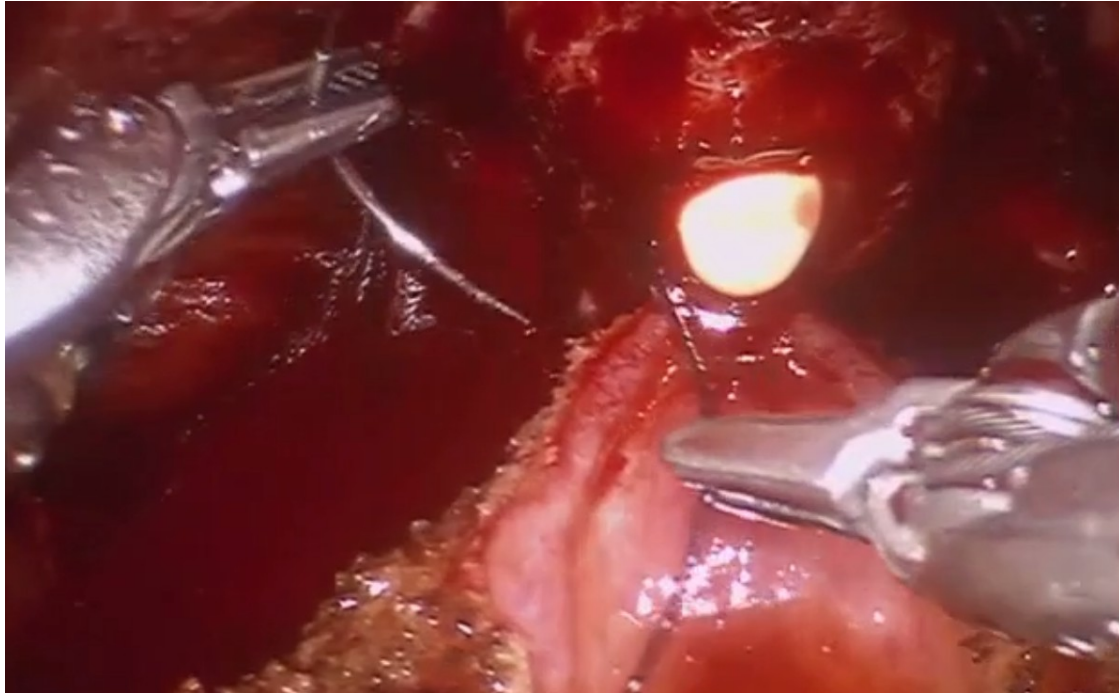


No clear pathway towards surgical mastery

Suturing : A core skill



Assessing technique is hard




Small needle

Blurry image


Occlusions

End-to End Assessment of Suturing Expertise (EASE)


Needle Repositions




Needle Hold Ratio



Needle Hold Angle

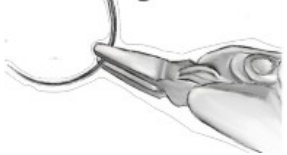


Depth of Needle Hold

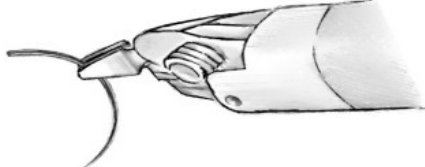


Handling

Driving Smoothness




Wrist Rotation



Driving

Wrist Rotation



Withdrawal

Pros

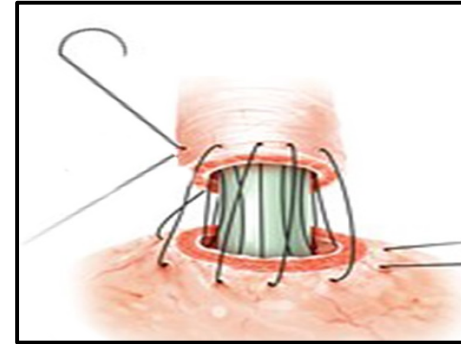
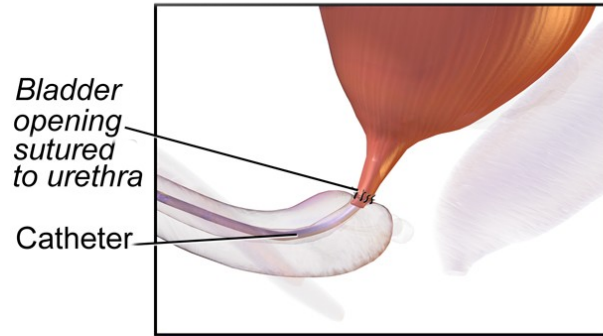
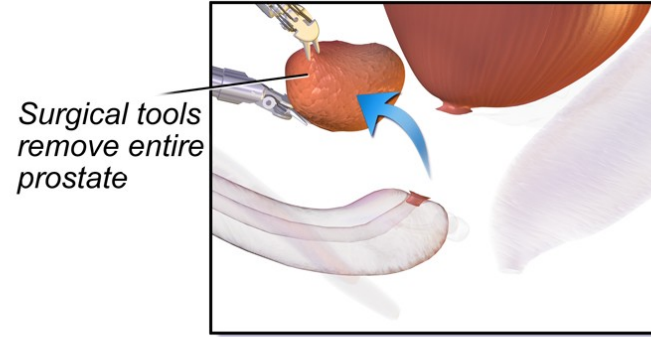
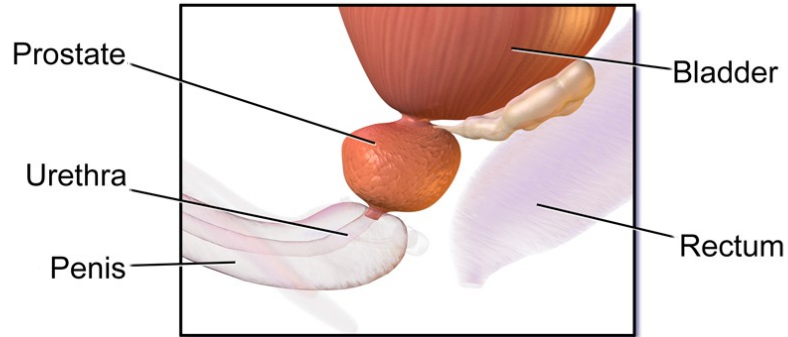
- Systematic
- Procedure-agnostic
- Clinically grounded

Cons

- Inter-rater agreement
- Manual review
- Domain knowledge

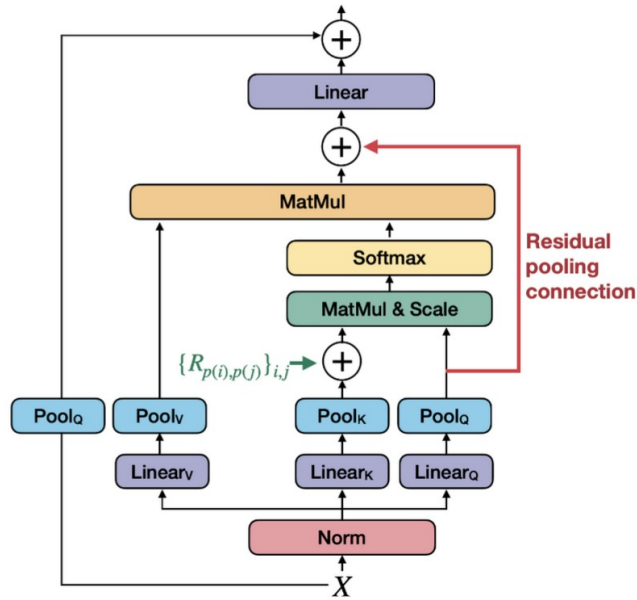
AutoEASE : An automatic suturing skill assessment system

Robot-assisted Radical Prostatectomy



80 videos X 24 stitches X 7 skills = 13000+ data points

Modeling Instrument Motion



MVIT V2 (Li et al. , 2022)

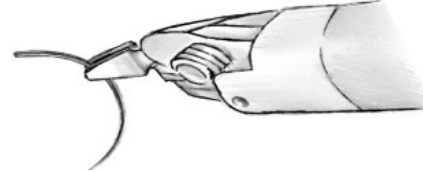
Needle Repositions



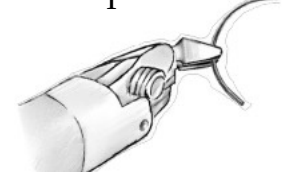
Driving Smoothness



Driving Wrist Rotation

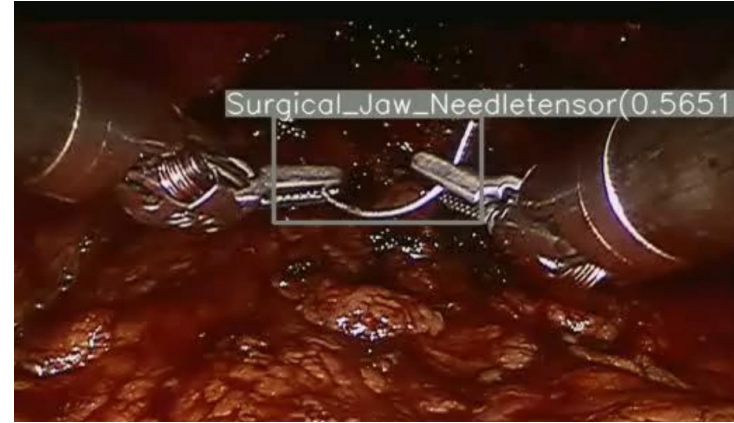
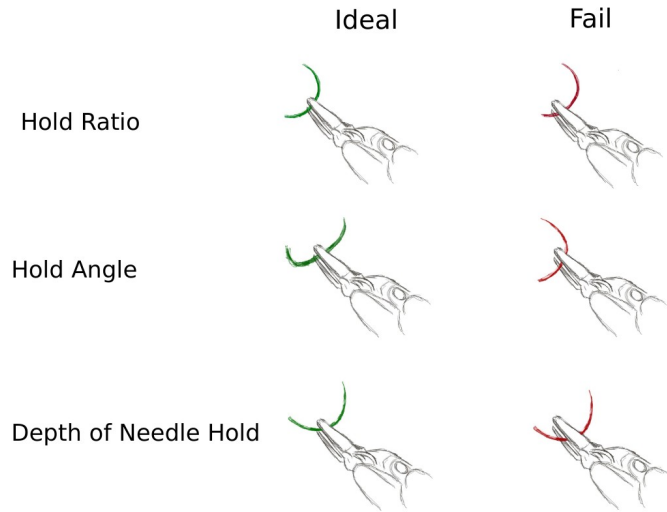


Withdrawa Wrist Rotation

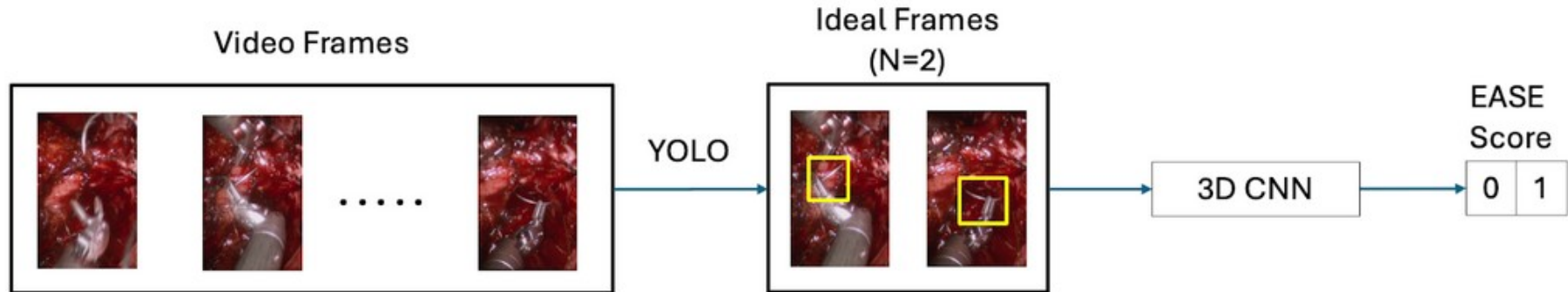


Ideal for movement-based skills

Tracking Needle Orientation



YOLO detector to target ideal frames

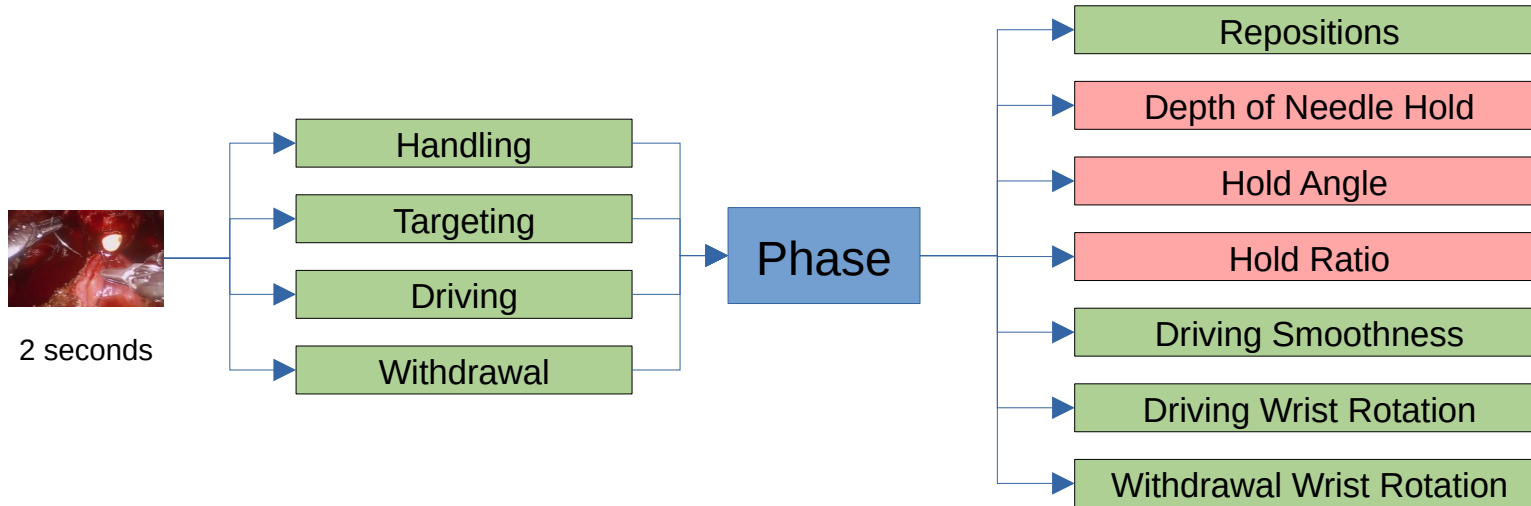


Mixture of Experts



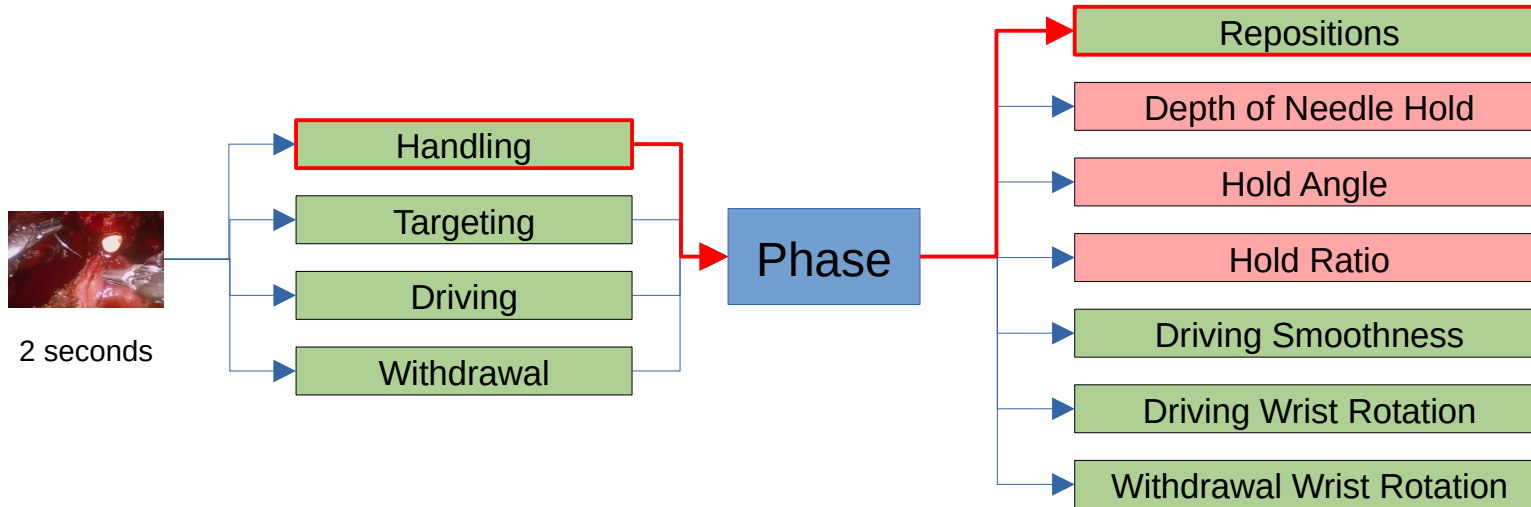
 : MViT

Mixture of Experts



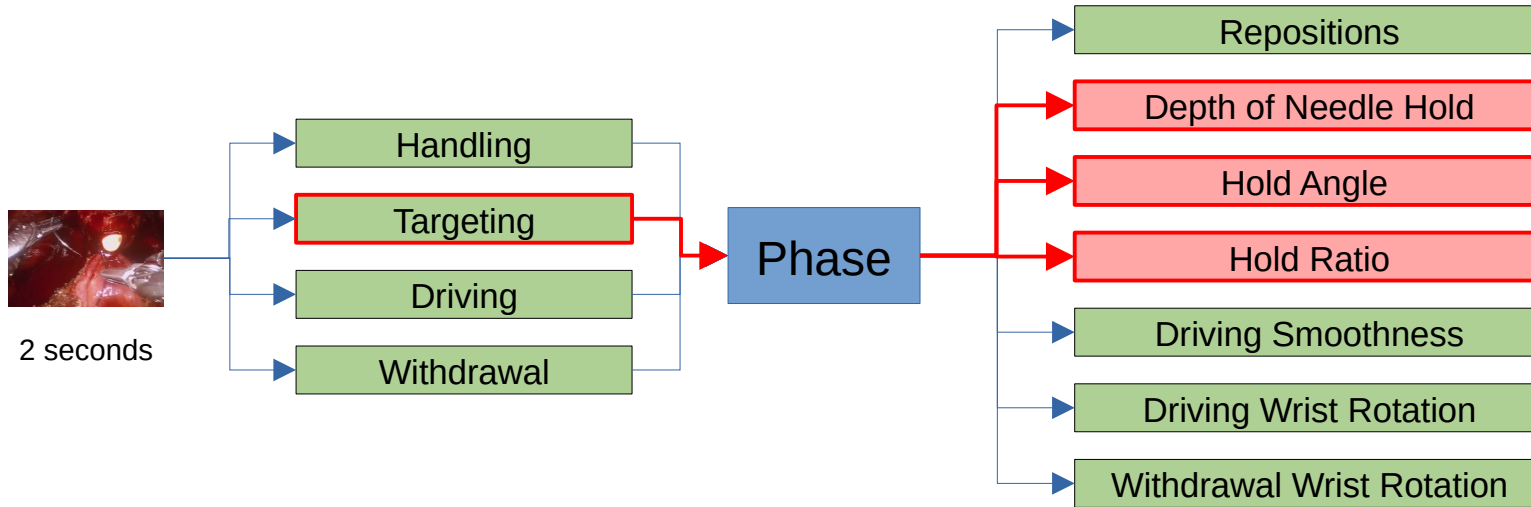
 : MViT
 : 3DCNN

Mixture of Experts



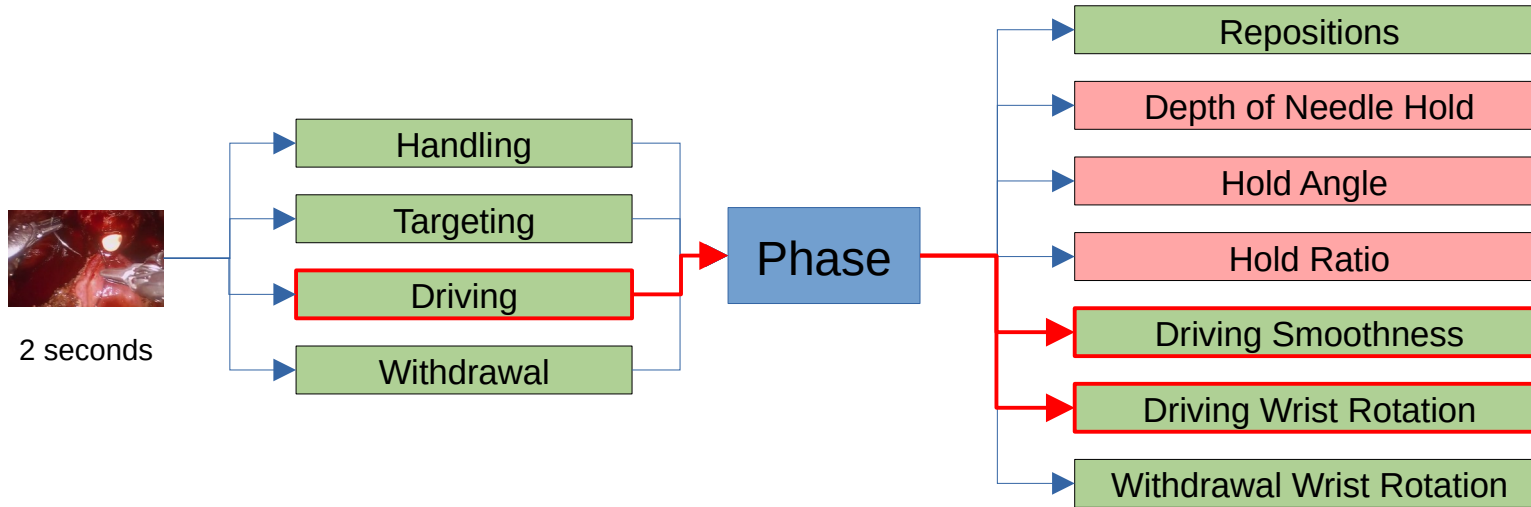
 : MViT
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Mixture of Experts



 : MViT
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Mixture of Experts



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End-to-End Pipeline Performance

Phase	Skill	AUC
Handling	→ Repositions	0.77
	→ Depth of Needle Hold	0.83
	→ Hold Angle	0.79
	→ Hold Ratio	0.77
Driving	→ Smoothness	0.81
	→ Wrist Rotation	0.78
Withdrawal	→ Wrist Rotation	0.60

Benchmarking

Phase Detection

Model	Needle Handling Recall	Needle Driving Recall	Needle Withdrawal Recall	Combined AUC
I3D (Baseline)	0.79	0.52	0.64	0.85
AutoEASE (Ours)	0.94	0.99	0.90	0.98

Benchmarking

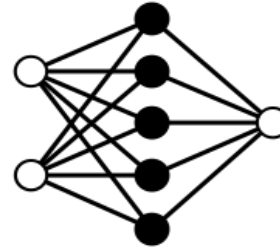
Skill Scoring

Skill	I3D AUC (Baseline)	AutoEASE AUC (Ours)
Handling Repositions	0.74	0.84
Depth of Needle Hold	0.69	0.82
Hold Angle	0.69	0.79
Hold Ratio	0.70	0.79
Driving Smoothness	0.72	0.78
Driving Wrist Rotation	0.72	0.75
Withdrawal Wrist Rotation	0.76	0.78

Application



1. Surgeon uploads
video



2. AI provides
skill report

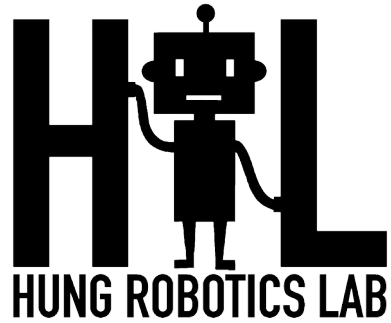


3. Surgeon improves
technique

Timely, **Reliable**, and **Constructive** feedback at scale

Future Work

- Improving Withdrawal skill assessment
- Scoring complete cases with multiple stitches
- Generalizing to other surgical procedures



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