Cost-Efficient Laparoscopic Haptic Trainer Based on Affine Velocity Analysis
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INTRODUCTION

- Learning minimal invasive surgery (MIS) skills is young surgeons’ major concern.
- Cognitive load elicited by simulators’ use and trainees’ spatial abilities seem to impact efficient learning process (1).
- Objectives: design a basic skill training simulator which objectively evaluate trainees’ level.
- Use of Affine velocity (2–3) as assessment variable.

METHODS

Step 1 - Cognitive conception
- Observation and analyses of surgeons in situ
- Inclusion of literatures’ recommendations

Spatial Abilities
Cognitive Load
Fundamentals of Laparoscopic Surgery

Step 2 - Simulator conception
- Use of materials enabling haptic feedback and developing a VR environment (Phantom Omni, CHAID, laparoscopic devices...)

WHAT IS AFFINE VELOCITY

Relationship between geometry and kinematic, first shown in 2D drawing: \[ \mathbf{v} = \mathbf{v}_0 K^{-1/3} \]
- With the curvature \( K \)

New power law for 3D movement: \[ \mathbf{v} = \mathbf{v}_0 K^\alpha |\mathbf{K}|^{\beta} \]
- With the torsion \( \tau \)
- \( \alpha \) and \( \beta \) are exponents that depend on the studied movement

Logarithmic linearization to find \( \alpha \) and \( \beta \) for laparoscopic gesture: \( \alpha = -0.048, \beta = -0.0026 \)

RESULTS

Panel of 77 subjects separated initially into 4 groups:
- Expert surgeon: more than 100 interventions
- Intermediate: between 5 and 20
- Unexperienced intern (BSS): witnessed but never performed
- Novice

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<th>Intermediate</th>
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Statistical test Kruskal and Wallis on affine velocity (above) can separate every groups but Experts and Intermediates, whereas collision alone could also not separate Novices from Unexperience Interns.

PCA with Expert and Intermediate fused with variables Collision, Time, and Affine Velocity

CONCLUSION

- A cognitive analysis of MIS enables to design a reliable and valid simulator.
- Affine velocity is a valid tool and another objective variable to evaluate a trainee skill on his trajectory.
- Once a certain level of skill is reached, it becomes harder to differentiate individuals.
- As feedback about skill level is displayed, the simulator should be effective in learning, this needs however to be confirmed by future investigations.

REFERENCES