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

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

Step 3 - Simulator validation
- Define assessment variables to evaluate the trajectory :
  - Time taken to complete the level
  - Number of errors (collisions)
  - Affine Velocity

WHAT IS AFFINE VELOCITY

New power law for 3D movement :
\[ v = v_0 K^{\alpha + \beta \theta} \]
- With the torsion \( \tau \)
- \( \alpha \) and \( \beta \) are exponents that depend of the studied movement

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

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.

RESULTS

<table>
<thead>
<tr>
<th></th>
<th>Intern</th>
<th>Expert</th>
<th>Intermediate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>P&lt;0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediates</td>
<td>P&lt;0.05</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Novice</td>
<td>P&lt;0.05</td>
<td>P&lt;0.05</td>
<td>P&lt;0.05</td>
</tr>
</tbody>
</table>

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