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

**INTRODUCTION**

- Affine velocity is a valid tool and another objective variable to evaluate Affine Velocity.
- With the curvature K

**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, CHAI3D, 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**

Relation between geometry and kinematic first shown in 2D drawing:

\[ v = v_K K^{-1/3} \]

- With the curvature K

New power law for 3D movement:

\[ v = v_K K^\alpha |\tau|\]

- With the torsion \( \tau \)
- \( \alpha \) and \( \beta \) are exponents that depend of the studied movement

Logarithmic linearization to find \( \alpha \) and \( \beta \) for laparoscopic gesture:

\[ \alpha = -0.048, \beta = -0.0026 \]

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

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>
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<th></th>
<th>Intern</th>
<th>Expert</th>
<th>Intermediate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
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<td>-</td>
<td></td>
</tr>
<tr>
<td>Intermediate</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**