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Cost-Efficient Laparoscopic Haptic Trainer Based on Affine Velocity Analysis

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Barnouin C.¹, De Witte B.², Moreau R.¹, Leleve A.¹, Martin X.³

¹ Univ Lyon, INSA Lyon, Ampère-UMR CNRS 5005, 25 av. Jean Capelle ouest-F- 69621 Villeurbanne Cedex, France.

² Univ Lyon, University Claude Bernard Lyon 1, Inter-University Laboratory of Human Movement Science, 27-29 Boulevard du 11 Novembre 1918, 69622, Villeurbanne cedex, France.

³ Univ Lyon, University Claude Bernard Lyon 1, Faculty of Medicine, Surgery school, 8 Avenue Rockefeller, 69003 Lyon, France



Surgetica 2017

INTRODUCTION

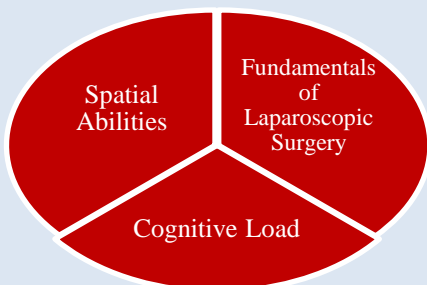
- ❖ Learning minimal invasive surgery (MIS) skills is young surgeons' major concern.
- ❖ Cognitive load elicited by simulators' use and trainees' spatial abilities seem to impact efficient learning process⁽¹⁾.
- ❖ Objectives : design a basic skill training simulator which objectively evaluate trainees'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

Step 1 - Cognitive conception

- Observation and analyses of surgeons in situ



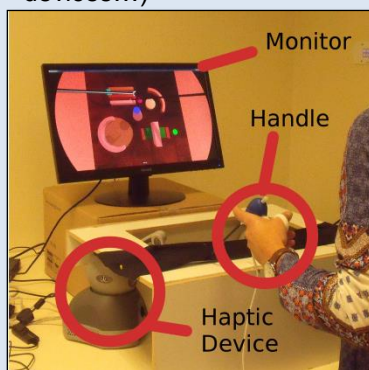
- Inclusion of literatures' recommendations



METHODS

Step 2 - Simulator conception

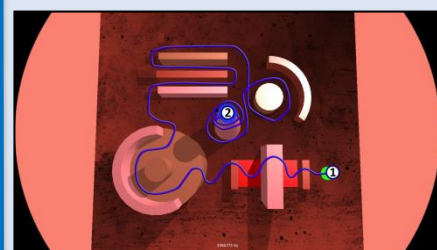
- Use of materials enabling haptic feedback and developing a VR environment (Phantom Omni, CHAI3D, laparoscopic devices...)



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

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

$$v = v_a K^{-1/3}$$

- With the curvature K



New power law for 3D movement :

$$v = v_a K^\alpha |\tau^\beta|$$

- With the torsion τ
- α and β are exponents that depend of the studied movement

Logarithmic linearization to find α and β for laparoscopic gesture : $\alpha = -0.048$, $\beta = -0.0026$

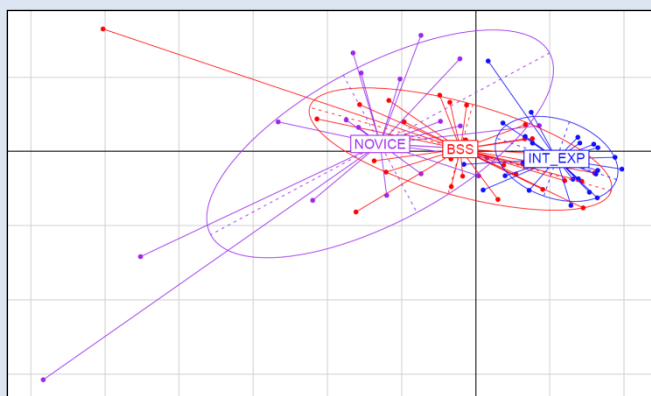
RESULTS

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

| | Intern | Expert | Intermediate |
|--------------|--------|--------|--------------|
| Expert | P<0.05 | - | - |
| Intermediate | P<0.05 | 0.43 | - |
| Novice | P<0.05 | P<0.05 | P<0.05 |

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.

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