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Cost-Efficient Laparoscopic Haptic Trainer Based on Affine Velocity Analysis

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Surgetica 2017

INTRODUCTION

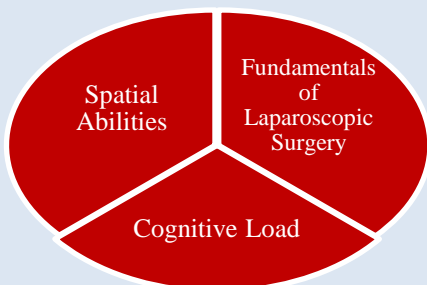
- ❖ Learning minimal invasive surgery (MIS) skills is young surgeons' major concern.
- ❖ Cognitive load elicited by simulators' use and trainees' spatial abilities seem to impact efficient learning process⁽¹⁾.
- ❖ Objectives : design a basic skill training simulator which objectively evaluate trainees'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

Step 1 - Cognitive conception

- Observation and analyses of surgeons in situ



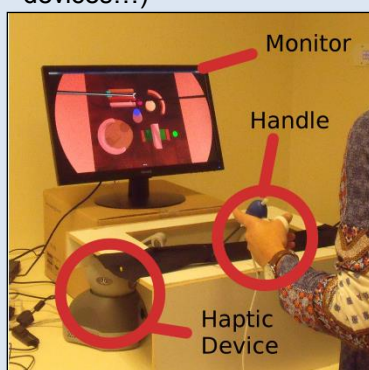
- Inclusion of literatures' recommendations



METHODS

Step 2 - Simulator conception

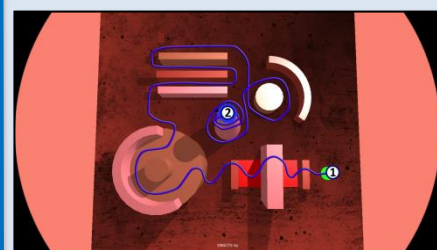
- Use of materials enabling haptic feedback and developing a VR environment (Phantom Omni, CHAI3D, laparoscopic devices...)



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 : $\alpha = -0.048$, $\beta = -0.0026$

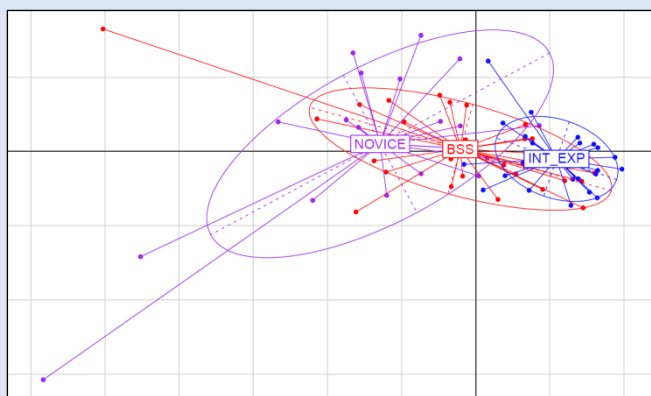
RESULTS

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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