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

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INTRODUCTION

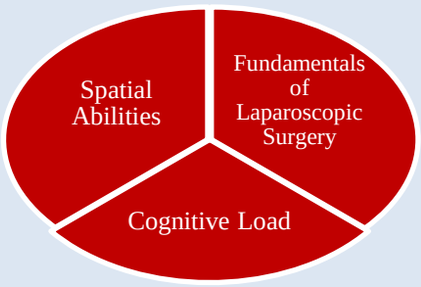
- Learning minimal invasive surgery (MIS) skills is young surgeons' major concern.
- Cognitive load elicited by simulators' use and trainees' spatial abilities seem to impact efficient learning process(1).
- Objectives : design a basic skill training simulator which objectively evaluate trainees' level.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

METHODS

Step 1 - Cognitive conception

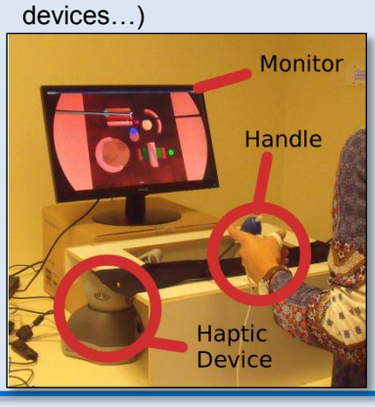
- Observation and analyses of surgeons in situ


- Inclusion of literatures' recommendations



Step 2 - Simulator conception

- Use of materials enabling haptic feedback and developing a VR environment (Phantom Omni, 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 : $\boldsymbol{\alpha = -0.048}$, $\boldsymbol{\beta = -0.0026}$

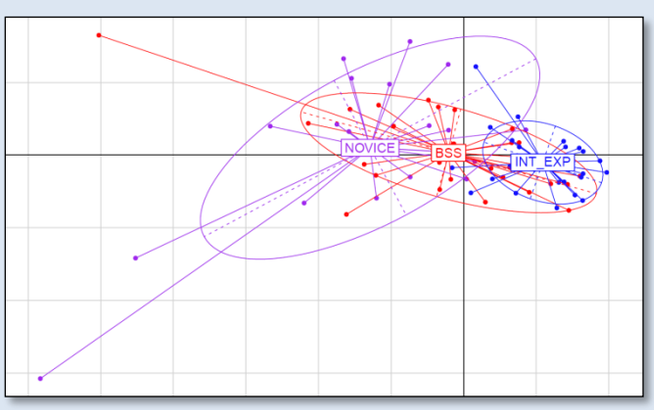
RESULTS

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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