aviesan
alliance nationale pour les sciences de la vie et de la santé

Institut Thématique Multi-Organismes
Technologies pour la santé

Bloc Chirurgical du Futur : Réalité virtuelle, Robotique et Science des Données Chirurgicales

Pierre Jannin

LTSI
INSERM, University of Rennes 1
http://medicis.univ-rennes1.fr

11ème journée ITS – 2 & 3 octobre 2019 – Rennes – https://its.aviesan.fr

1

2

3

Surgical Quality

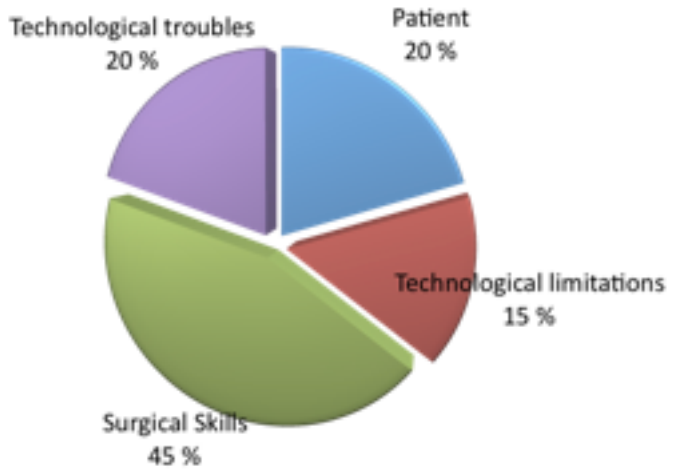
- 250 M./y Surgical procedures
- Preventable perioperative severe adverse events (with mortality consequences) 0.5 - 1 %
- Airplanes Worldwide: < 0.005 %

[Kazrick, 05], [Leape, Berwick, 95], [IoM, 00]

4

USA

5



Adverse events in robotic surgery

6

Technical Skills Non-Technical Skills

Motor Skills / Dexterity | Conceptual Knowledge | Procedural K | Cognitive skills | Interpersonal skills

7

« Learning on patients »

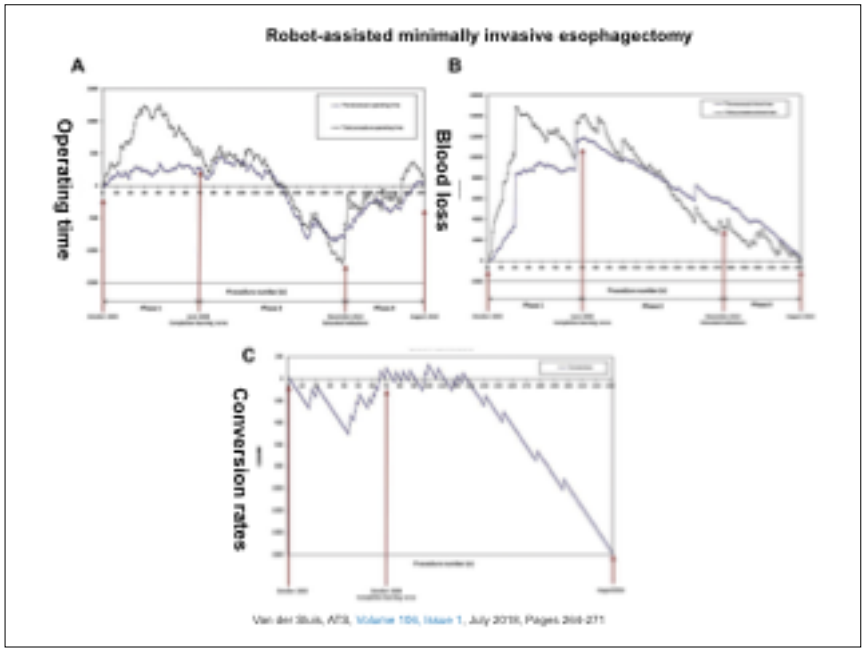
Residents

Cholecystectomy **100 procedures**
Appendicectomy **30** procedures
Radical Prostatectomy **200-250** procedures

Experts

Major Hepatectomy **45-75** procedures
Unique trocart Cholecystectomy **20** procedures
Robotic Assisted radical Prostatectomy **100-300** procedures

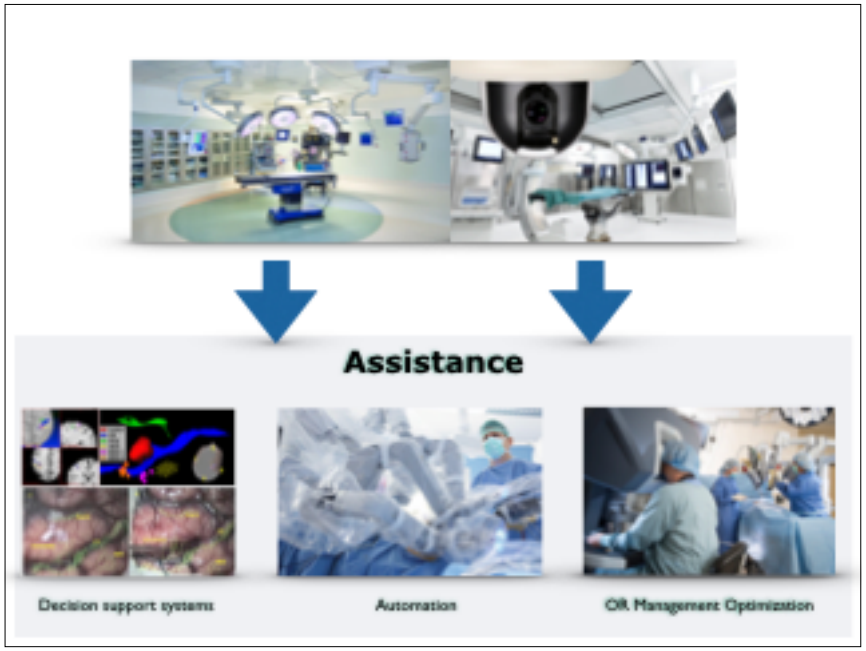
8


Robot-assisted minimally invasive esophagectomy
A
B
C
Operating time
Blood loss
Conversion rates

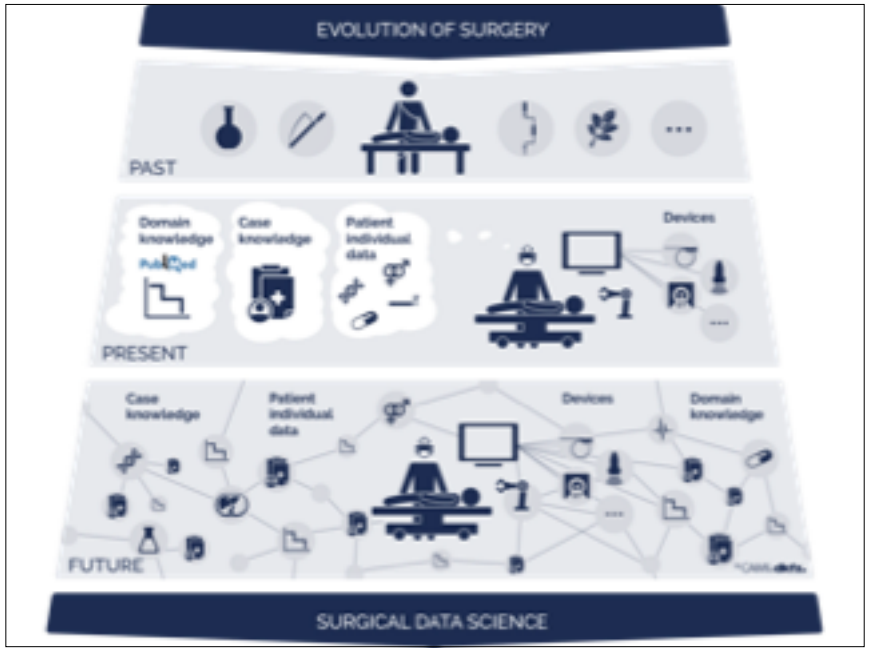
9


Training/Evaluation
Traceability - QC
Learning
Assessment

10


Assistance
Decision support systems
Automation
OR Management Optimization

11


EVOLUTION OF SURGERY
PAST
PRESENT
FUTURE
SURGICAL DATA SCIENCE

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Improving Surgical Quality
With

Surgical Data Science

Nature Biomedical Engineering 2018

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Surgical Data Science

Nature BME 2018

15

Data

Information

Knowledge

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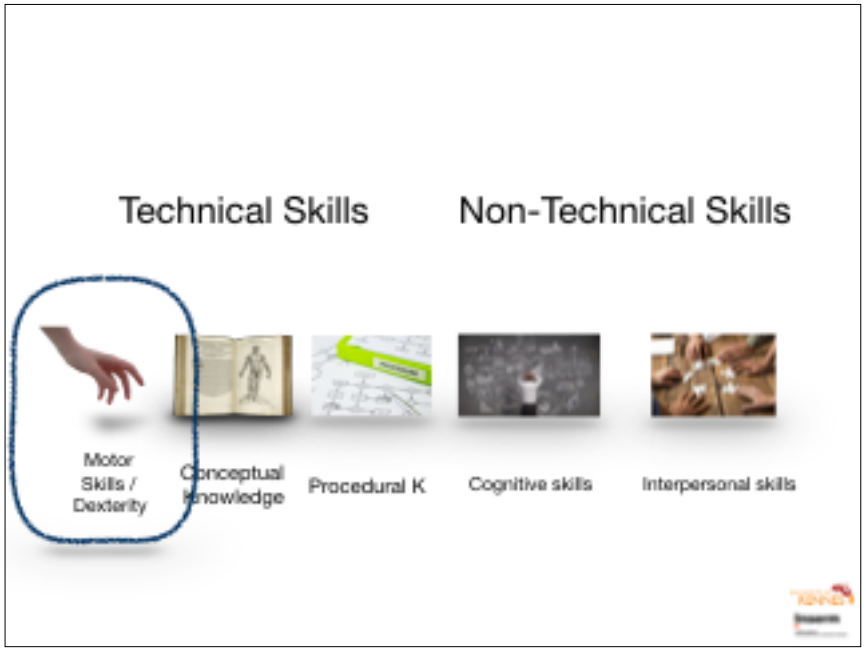
CAMI
COMPUTER ASSISTED MEDICAL INTERVENTIONS
INTUITIVE
stryker
ImPACT

18



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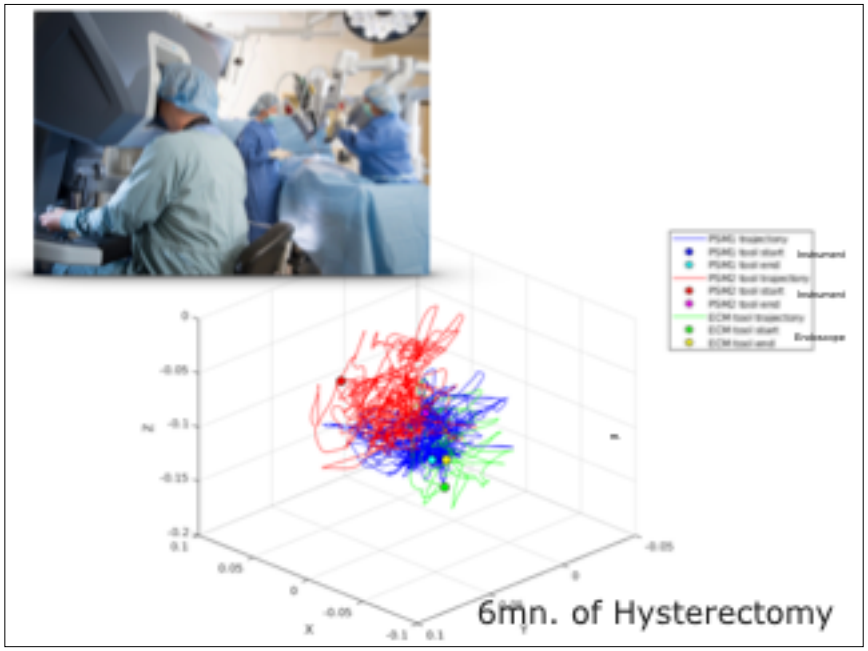

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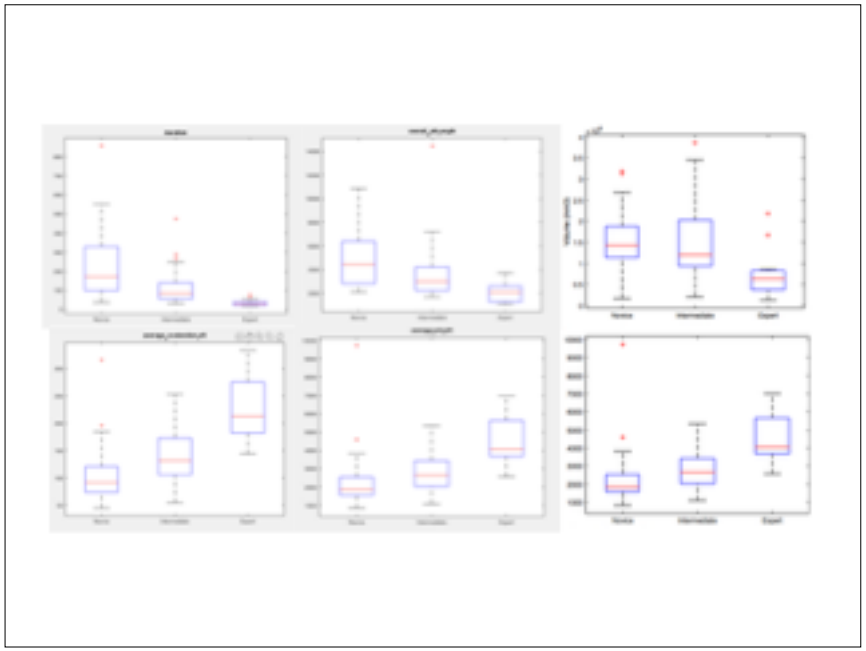

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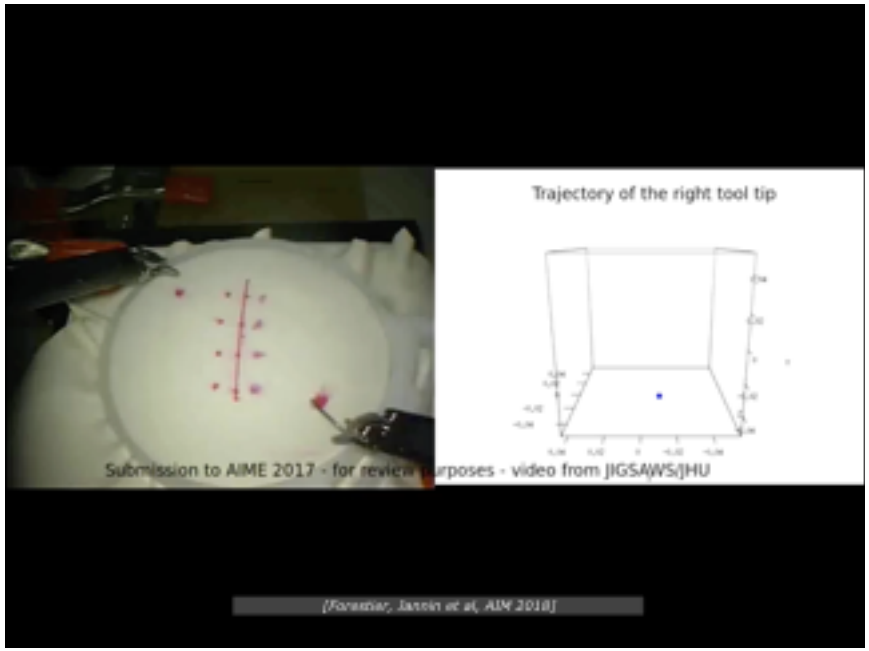
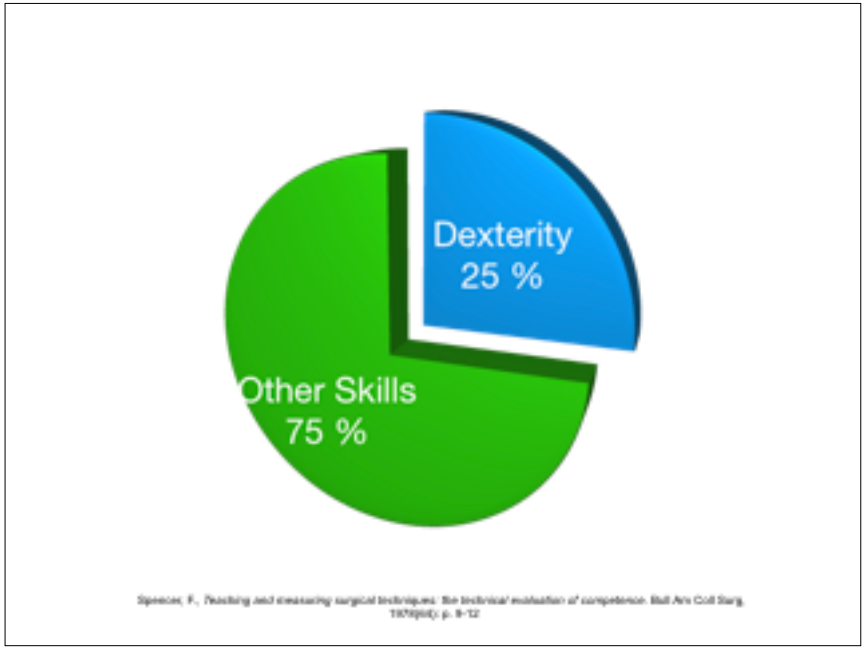

Trajectory of the right tool tip
Submission to AIME 2017 - for review purposes - video from JIGSAWS/JHU
[Forestier, Jannin et al, AIM 2018]

22

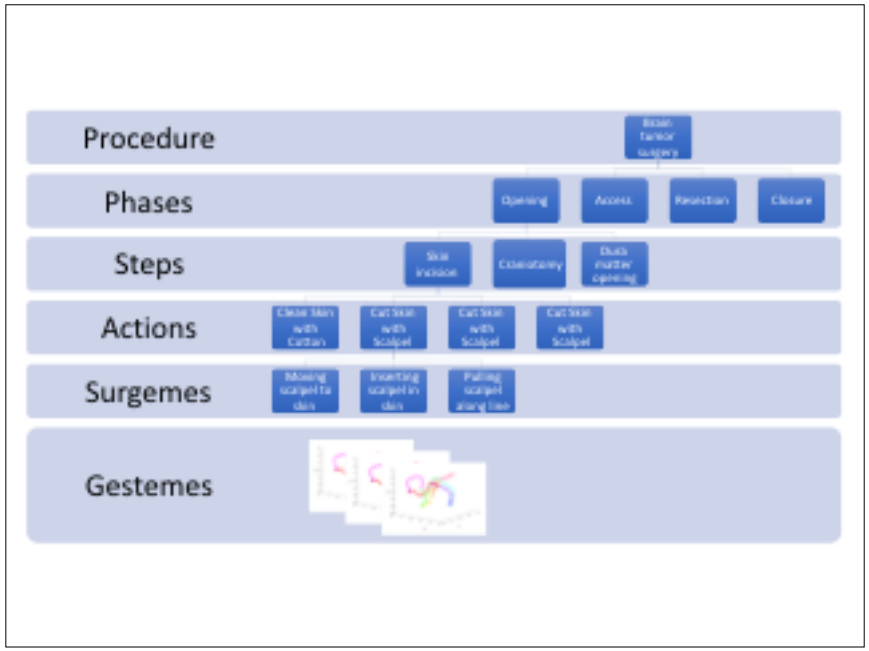

Dexterity
25 %
Other Skills
75 %

23


Technical Skills
Non-Technical Skills
Motor Skills / Dexterity
Conceptual Knowledge
Procedural K
Cognitive skills
Interpersonal skills

24

25



26

OntoSPM Initiative

- Freely available

http://ontospm.univ-rennes1.fr

27

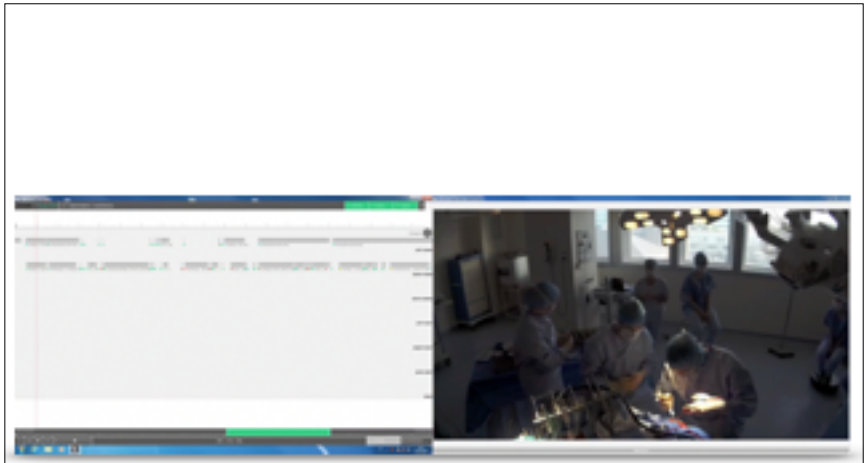
[Gibaud et al, IJCARS 2018, SURGETICA 2014]

27

28

[Neumuth, Jannin et al, JAMIA 2009]

29



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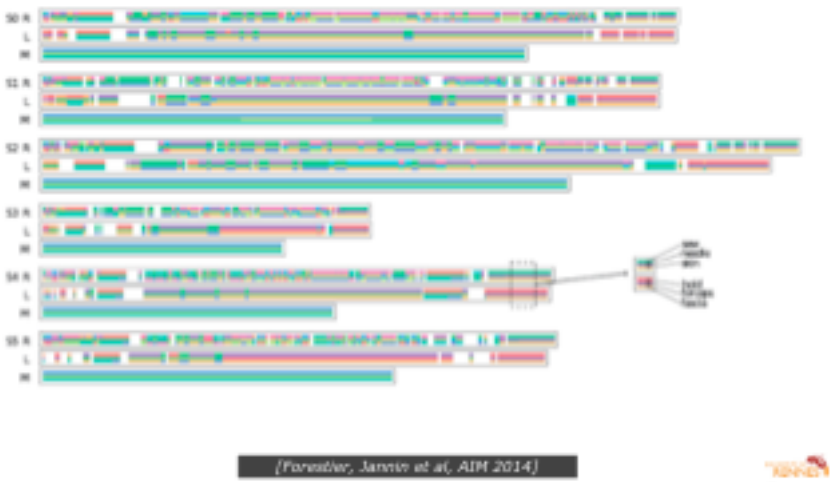
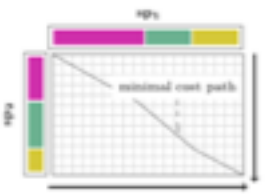
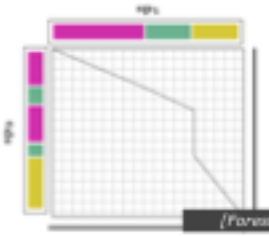


[Forestier, Jannin et al, AIM 2014]

31

Using Dynamic Time Warping



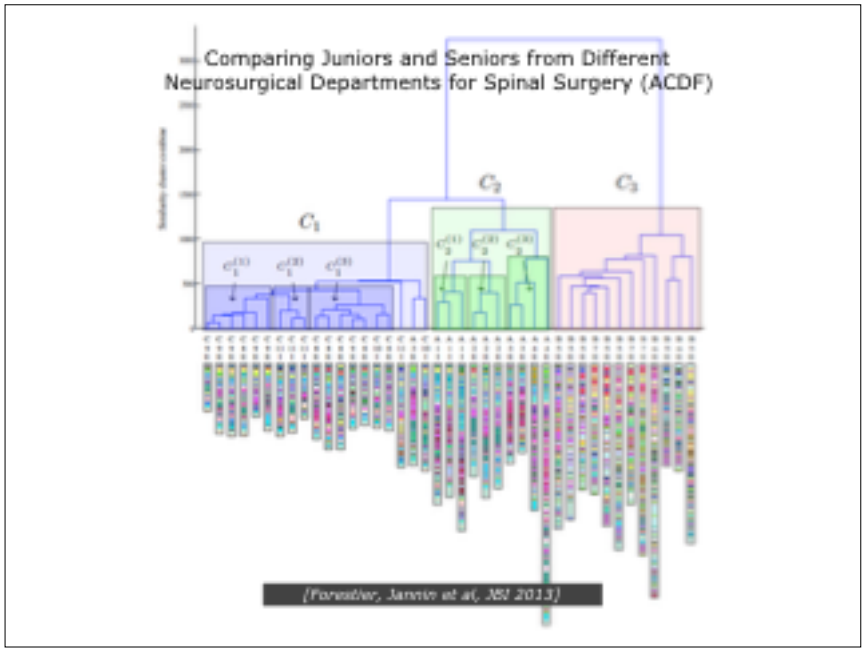


- Distance between two SPMs
- Independant from duration of activities

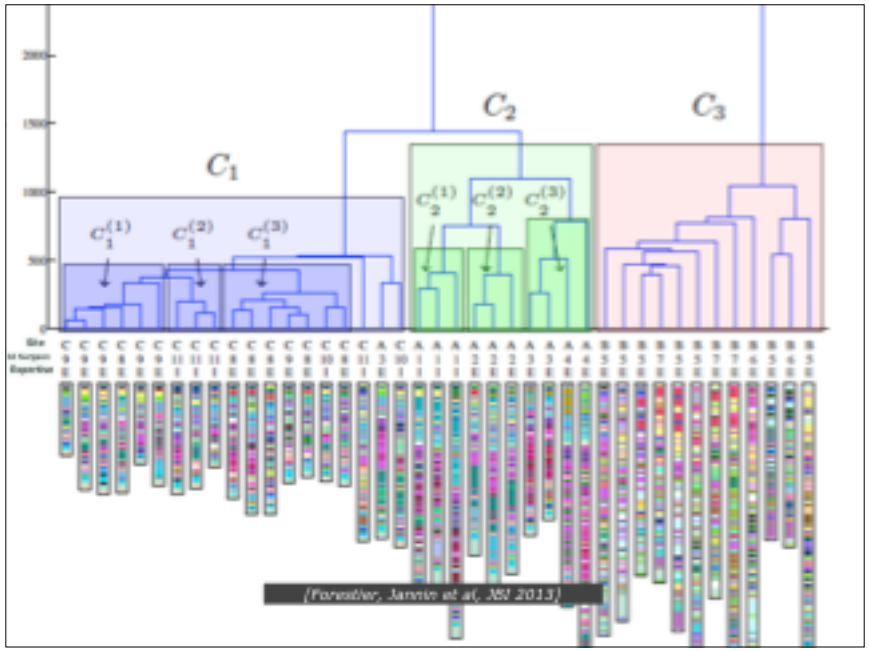
[Forestier, Jannin et al, IJBI 2011]

32

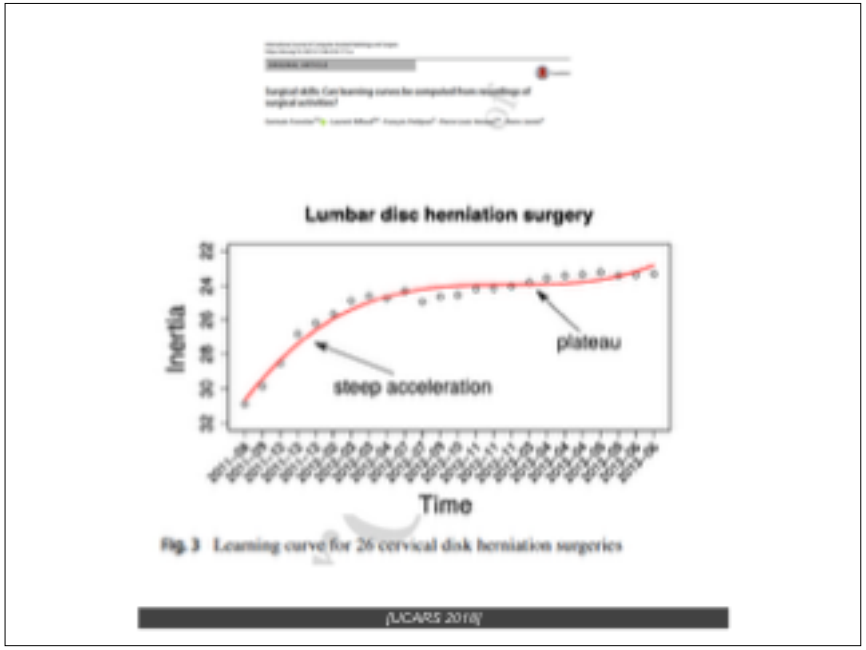
32


Comparing Juniors and Seniors from Different Neurosurgical Departments for Spinal Surgery (ACDF)
C_1
C_2
C_3
[Forestier, Jannin et al, JBI 2013]

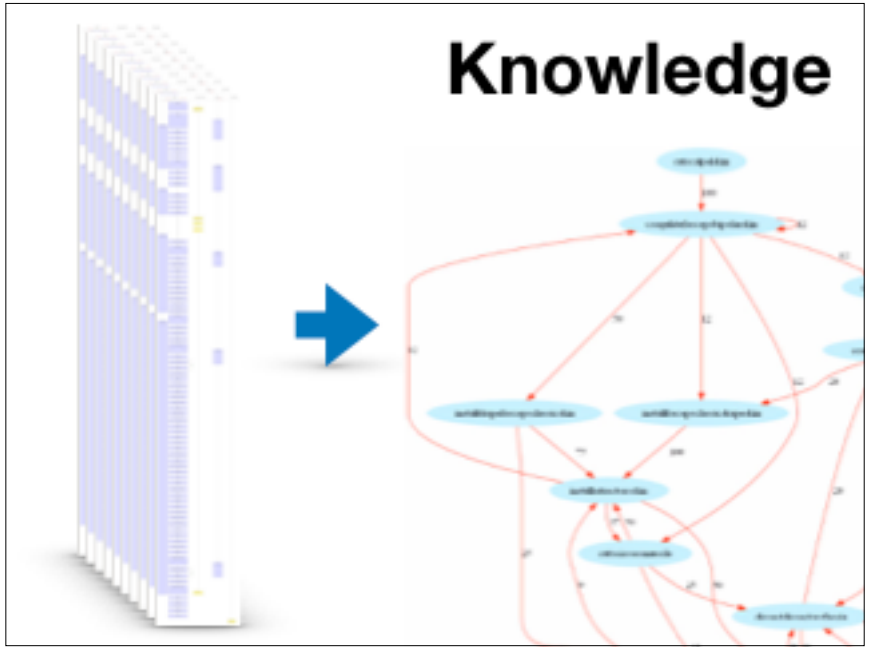
33


C_1
C_2
C_3
[Forestier, Jannin et al, JBI 2013]

34


Lumbar disc herniation surgery
Inertia
plateau
steep acceleration
Time
Fig. 3 Learning curve for 26 cervical disk herniation surgeries
[IJCARS 2016]

35


Knowledge

36

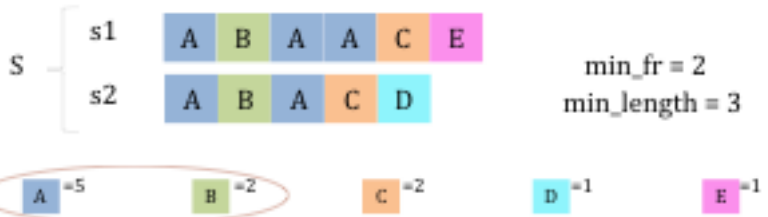
Closing Phase of LDH Rennes
for 12 Patients

37

Surgical Sequential Signatures

[A. Huaulmé, P.Jannin IJCARS 2018]

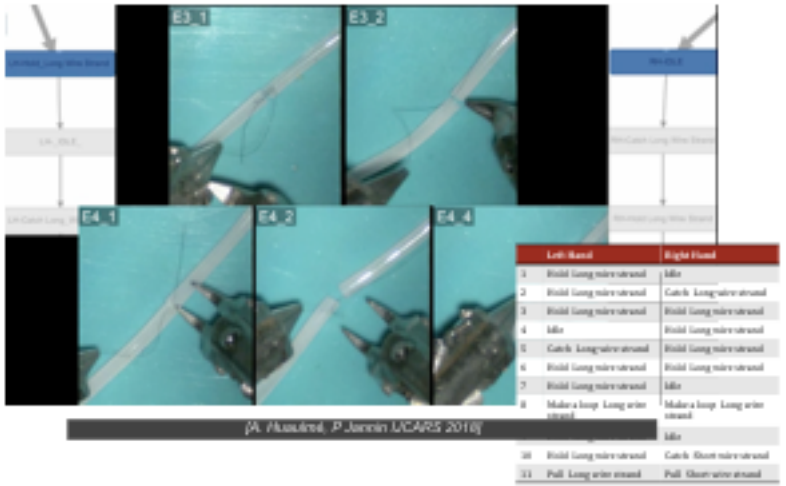
38



[A. Huaulmé, P.Jannin IJCARS 2018]

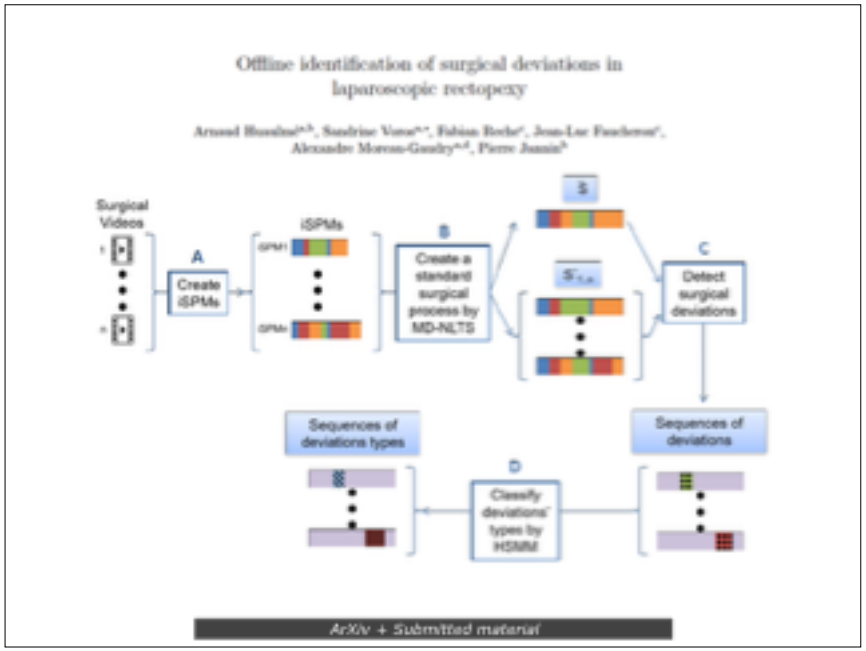
39

- Experts' surgical signature
  - In 5 expert's sequences
  - Succession of 11 activities



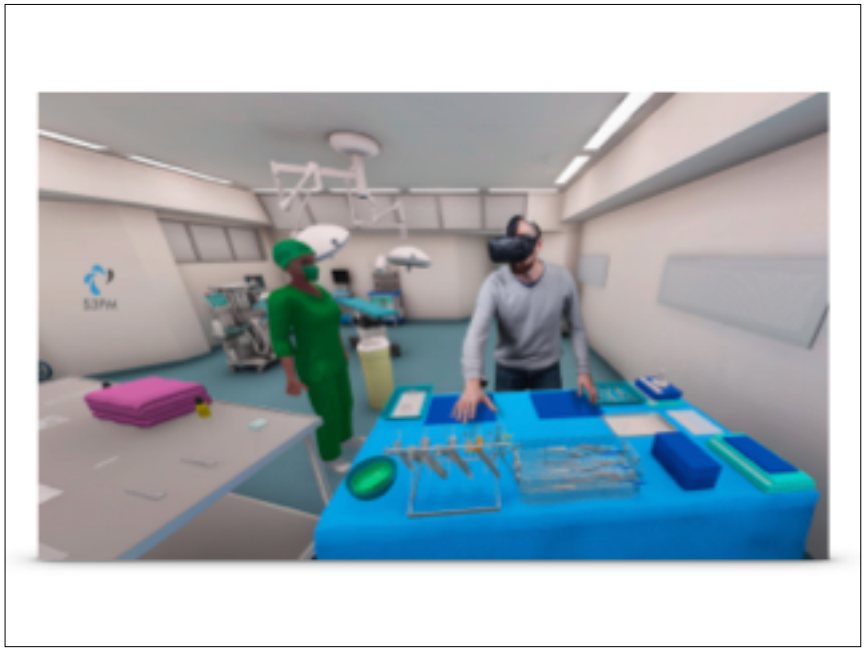
[A. Huaulmé, P.Jannin IJCARS 2018]

40



41

42



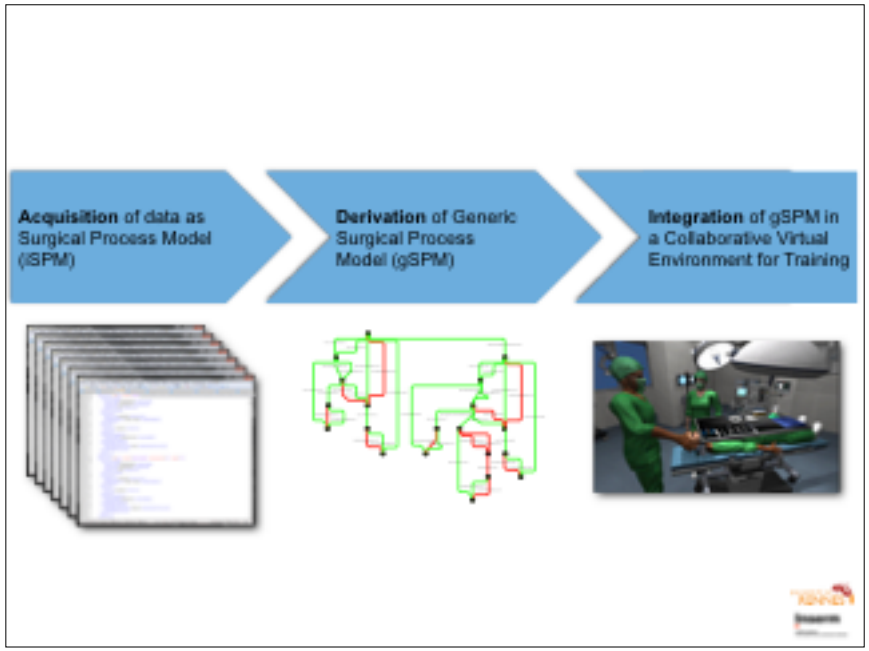
43

ComInLabs

44


Technical Skills
Non-Technical Skills
Motor Skills / Dexterity
Conceptual Knowledge
Procedural K
Cognitive skills
Interpersonal skills

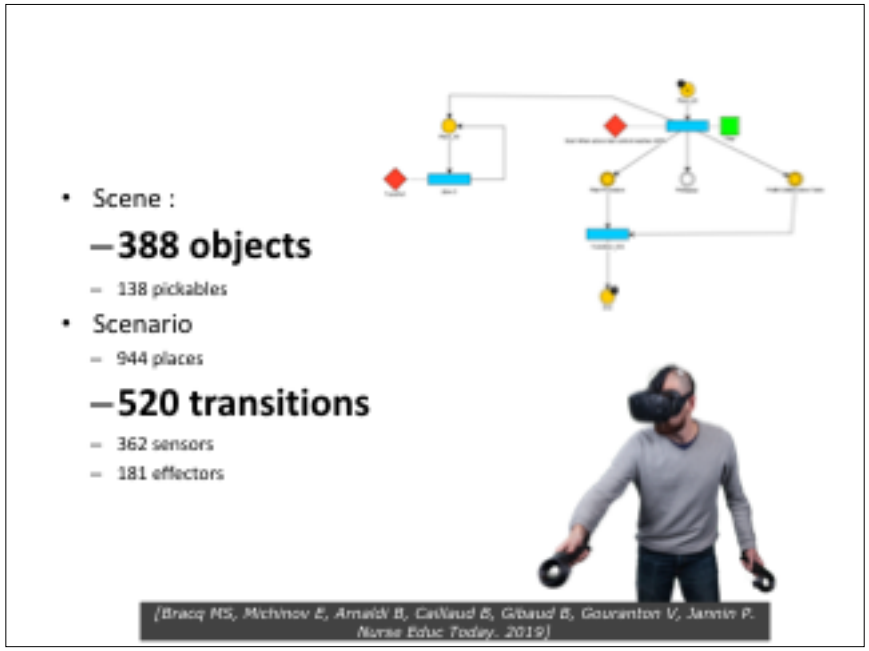
45


Acquisition of data as Surgical Process Model (iSPM)
Derivation of Generic Surgical Process Model (gSPM)
Integration of gSPM in a Collaborative Virtual Environment for Training

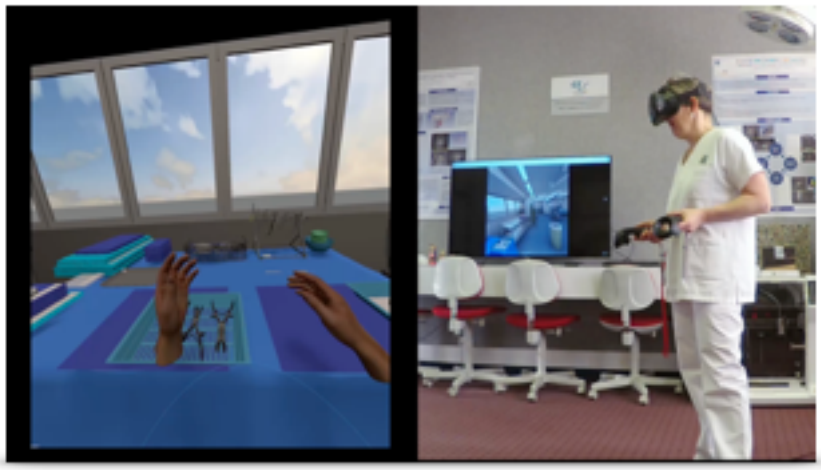
46


[Bracq MS, Michinov E, Arnaldi B, Caillaud B, Gibaud B, Gouranton V, Jannin P. Nurse Educ Today. 2019]

47

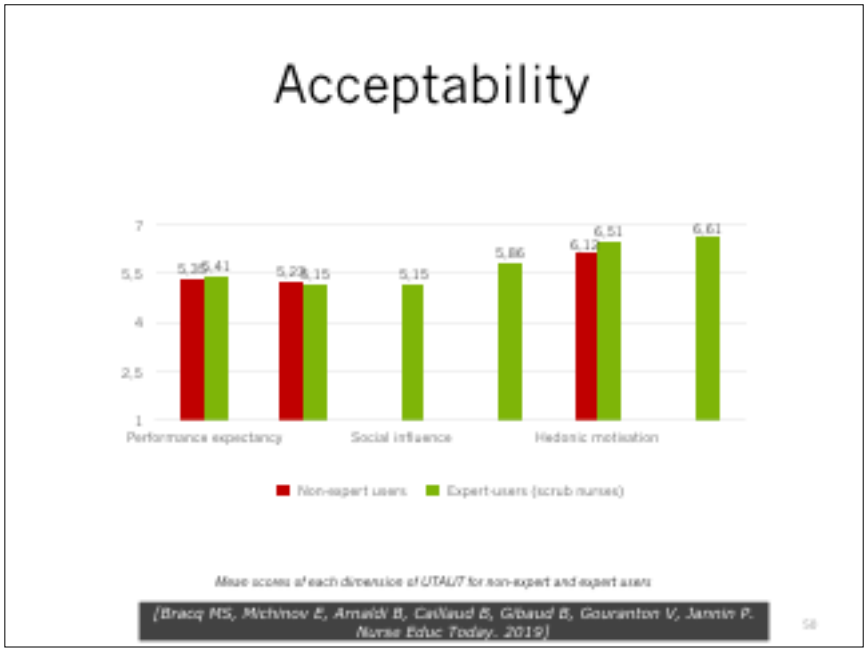

Scene :
388 objects
138 pickables
Scenario
944 places
520 transitions
362 sensors
181 effectors
[Bracq MS, Michinov E, Arnaldi B, Caillaud B, Gibaud B, Gouranton V, Jannin P. Nurse Educ Today. 2019]

48



[Bracq MS, Michinov E, Arnaldi B, Caillaud B, Gibaud B, Gouranton V, Jannin P. Nurse Educ Today. 2019]

49



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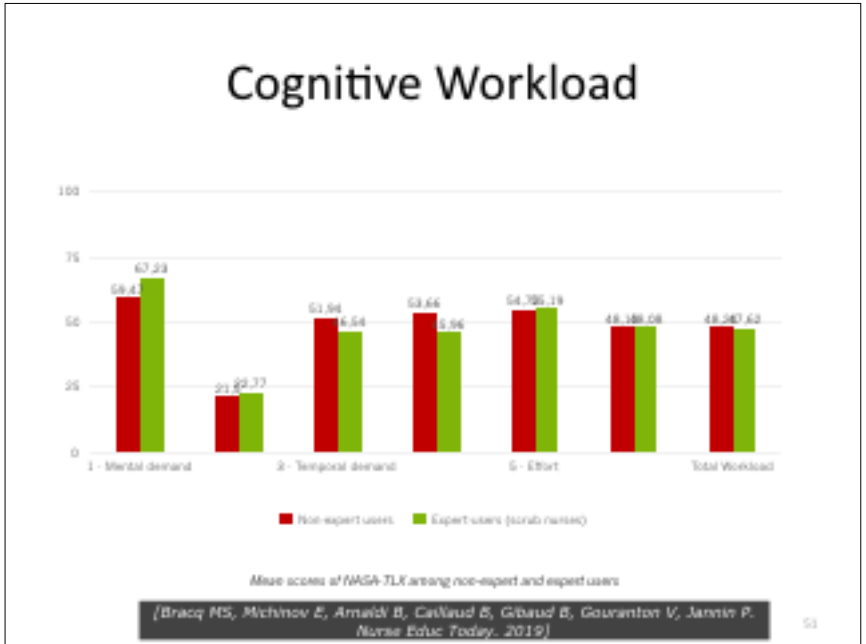
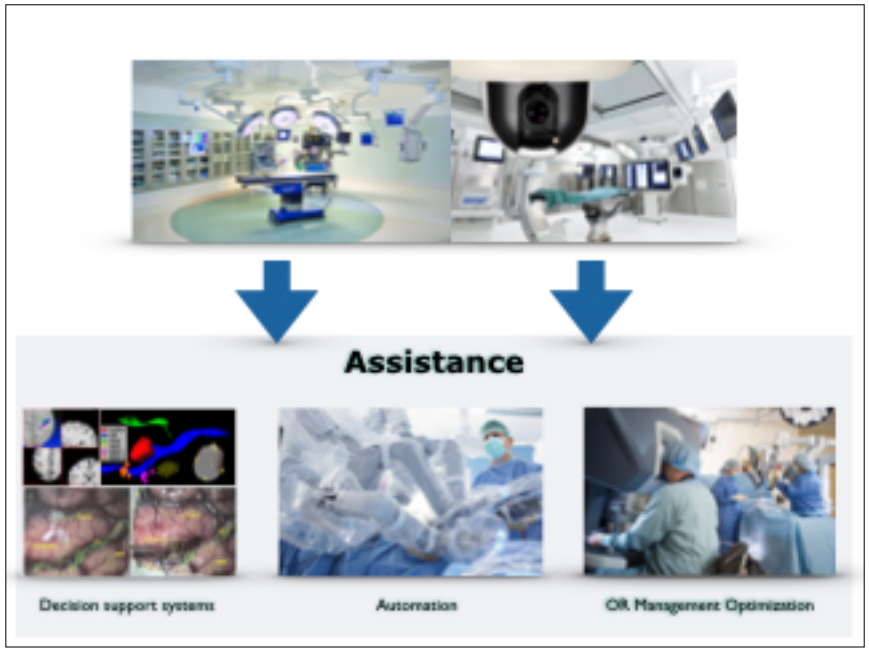


51

52

53



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ImPACT Program
Bionic Humanoids Propelling New Industrial Revolution
Japan Science and Technology Agency
Partners
CONDOR
Connected Optimized Network & Data in Operating Rooms
bpifrance
Partners

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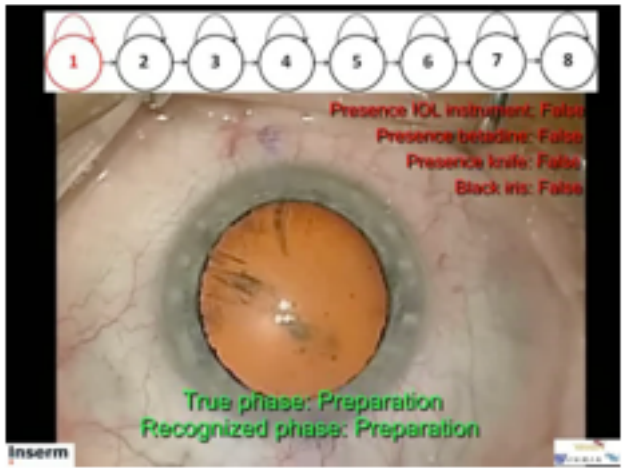
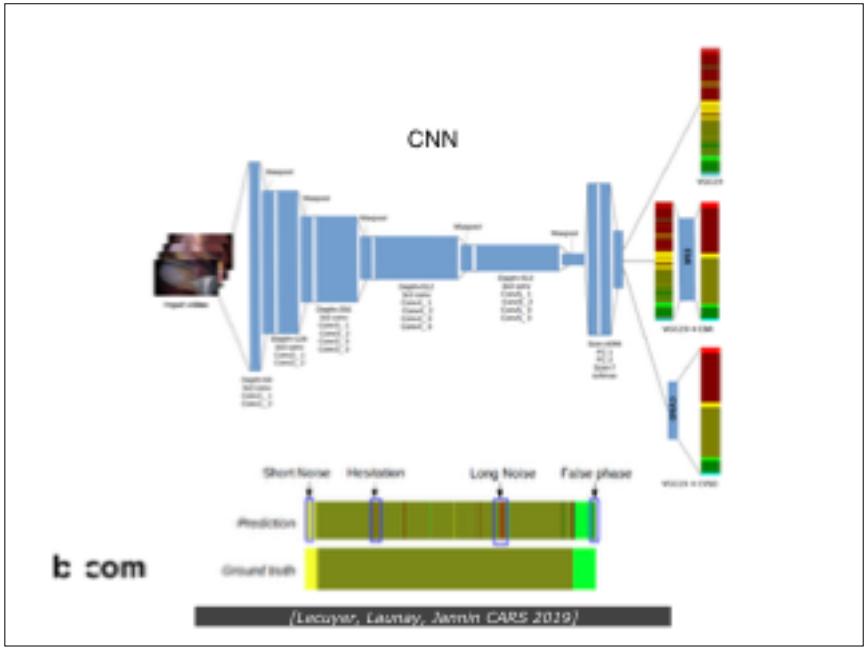


[Lalys, Jannin et al, IEEE TBE 2012, IPCAI 2011, MICCAI 2011]

57



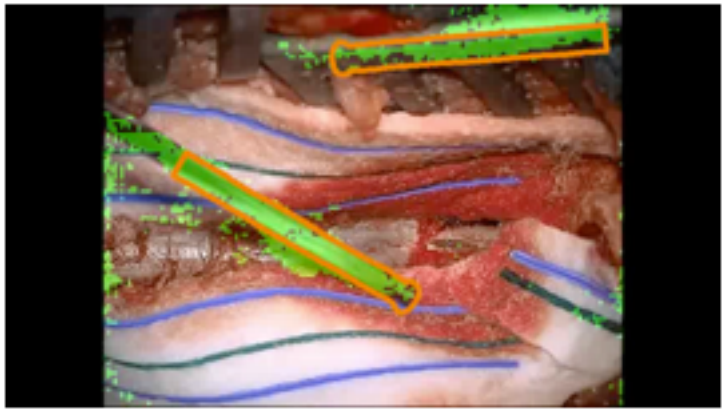
[Lecuyer, Launay, Jannin CARS 2019]

58

	Avg Accuracy	Avg Precision	Avg Recall
EndoNet w/o HHMM	75.2±0.9	70.0±8.4	66.0±12.0
VGG19	77.9±11.7	65.9±13.3	69.7±13.5
Chen et al.[3]	N/A	85.8	74.9
VGG19, Loukas et al. [13]	78	77	78
ResNet101, Loukas et al. [13]	86	**88**	**86**
EndoLSTM	83.0±10.8	77.5±24.0	77.2±24.2
EndoN2N	86.7±9.3	81.4±23.0	80.9±22.1
SV-RCNet [9]	81.7±8.1	81.0±8.3	81.6±7.2
VGG19 + FbB	86.6±11.1	76.5±19.5	75.9±20.3
VGG19 + CVbD offline	**87.8±8.5**	80.9±9.5	79.3±15.0
VGG19 + CVbD online	84.4±10.4	75.2±11.6	73.6±16.7

[Lecuyer, Launay, Jannin CARS 2019]

59



NeuroSurgicalTools Data set

[Bouget, Jannin et al, IEEE TMI 2015, MedIA 2016]

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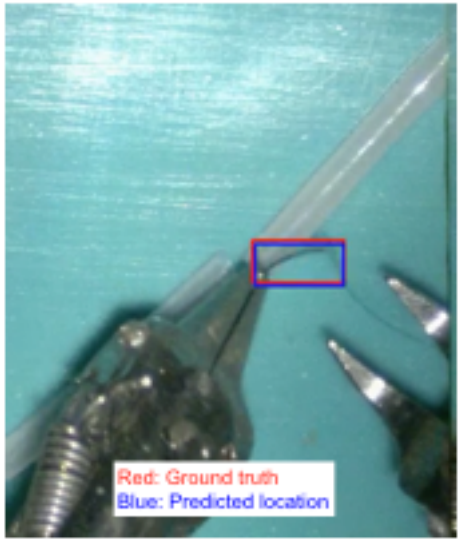
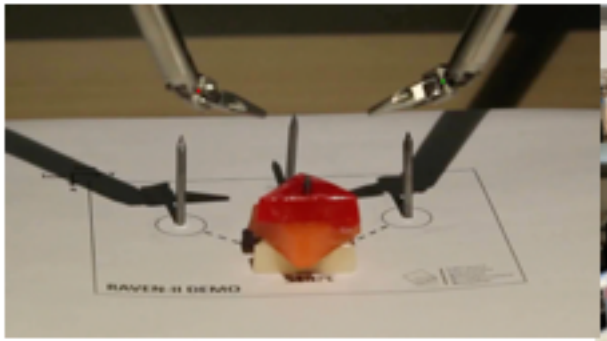
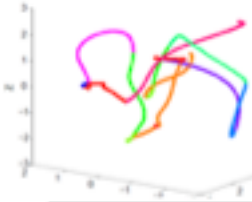
Faster R-CNN



(A. Nakazawa, K. Harada, M. Mitsuishi, P. Jannin, JCARS 2019)

61





(F. Despinoy, Bouget, Jannin, IEEE TBME 2015)

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Challenges of Deep Learning in Surgical Data Science

1. Lack of data
2. Cost of annotation
3. Insufficient validation
4. Difficulties in recognition of surgical activities

63

Visual	ImageNet	14M images
	Google's Open Images	9M images
	YouTube-8M	7M videos
Textual	Amazon reviews	3B words
	BDpedia	3.4M concepts

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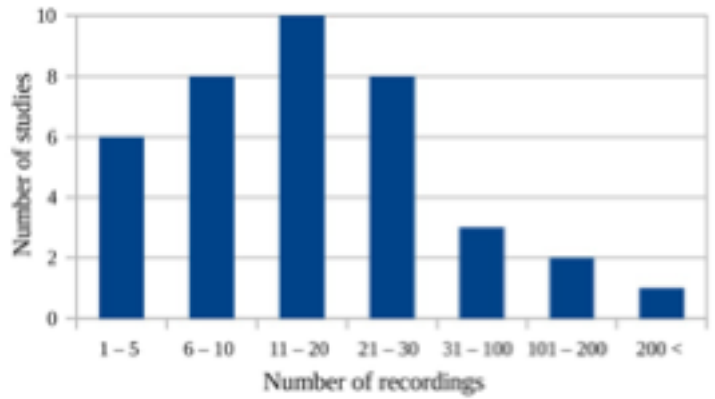

* Review of 34 publications (2007 – 2017) on surgical workflow recognition

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Lack of Data

- Data augmentation
- Transfer learning
  - Simulated data
  - Other areas
  - Other modalities
- Reinforcement learning
- Weak supervision
- Multi task learning
- Teacher/Student approach
- …

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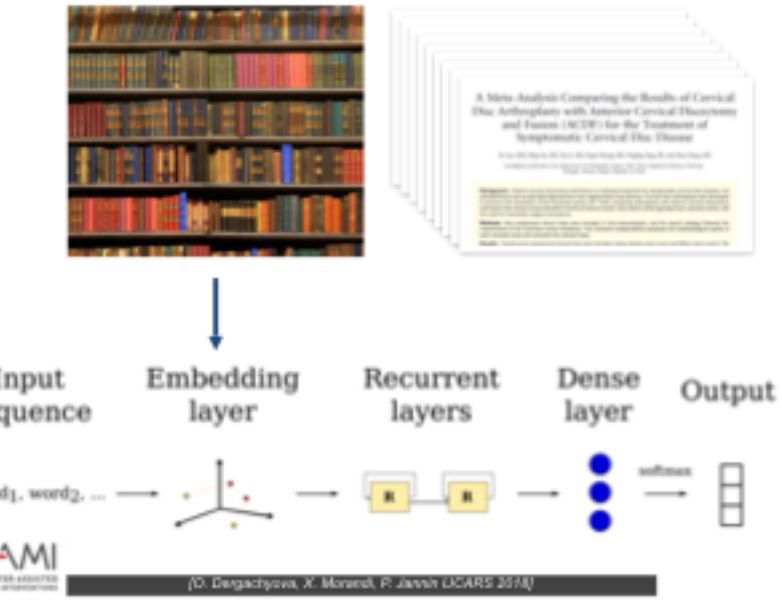

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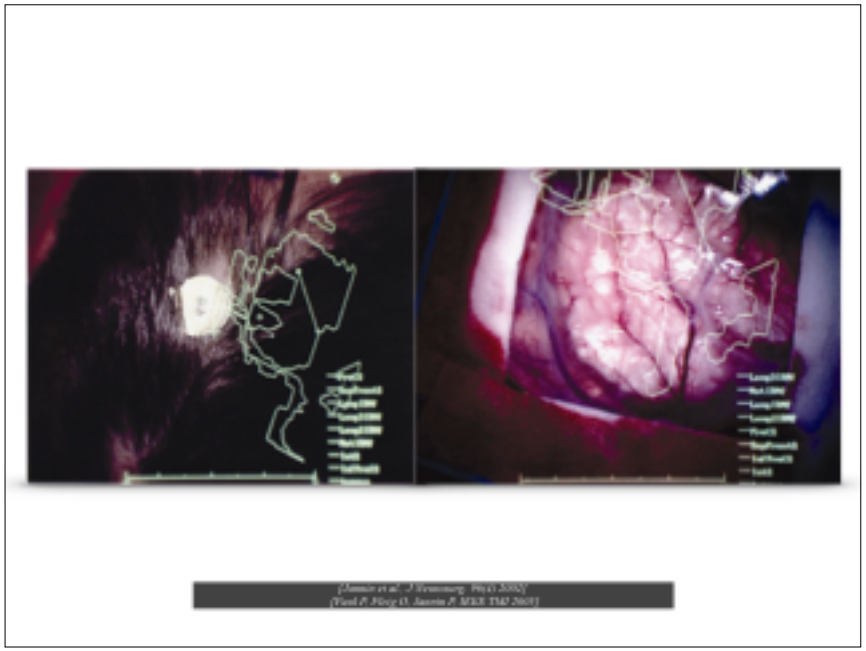
« The right information at the right moment … »

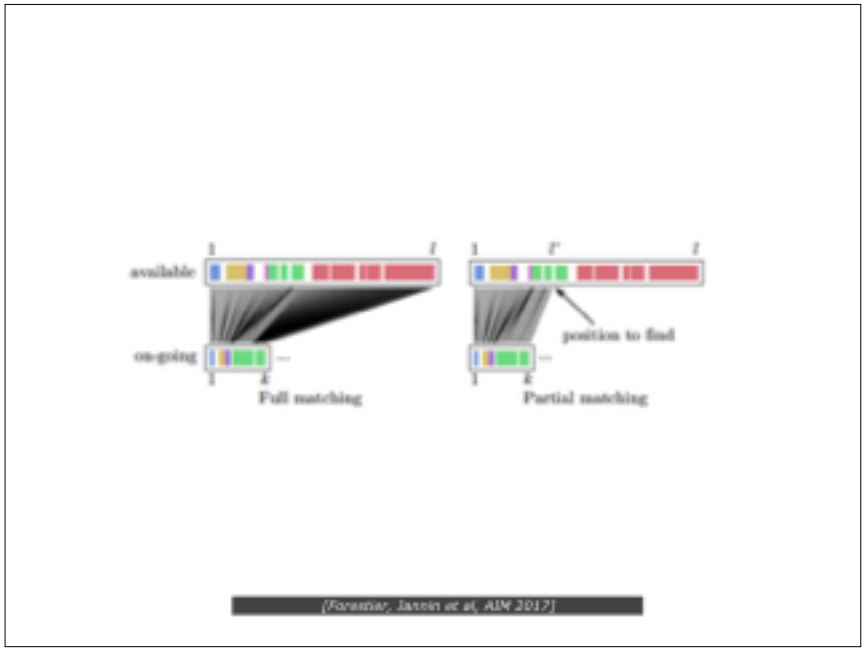
68



69


CONDOR

70


available
on-going
position to find
Full matching
Partial matching
[Forestier, Jannin et al, AIM 2017]

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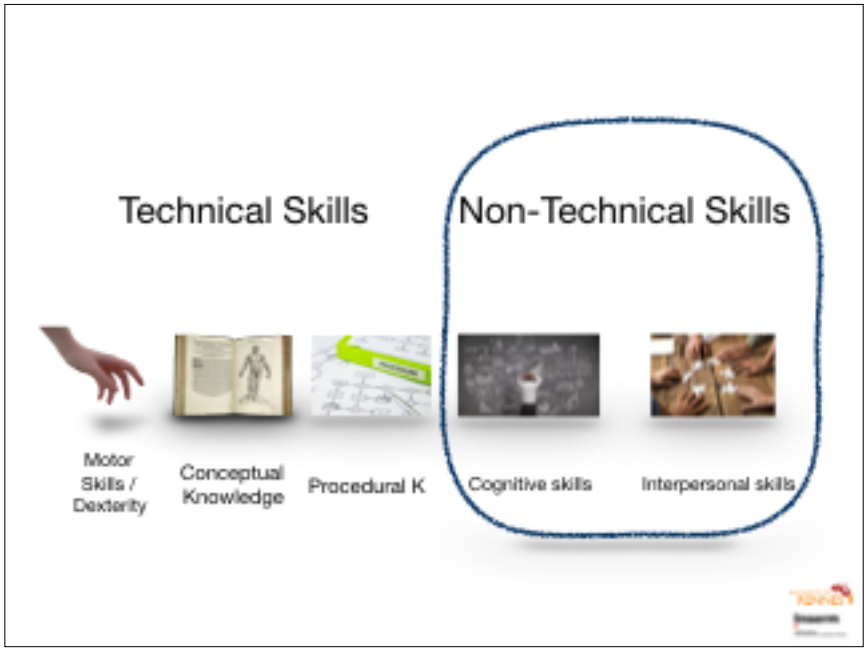
Technical Skills
Non-Technical Skills
Motor Skills / Dexterity
Conceptual Knowledge
Procedural K
Cognitive skills
Interpersonal skills

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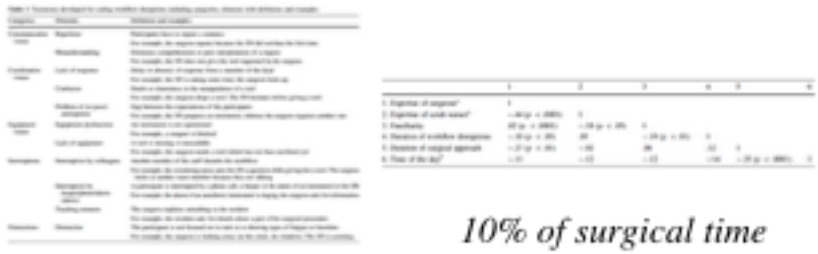
World J Surg
https://doi.org/10.1007/s00268-018-4805-5

ORIGINAL SCIENTIFIC REPORT

Relationships Between Expertise, Crew Familiarity and Surgical Workflow Disruptions: An Observational Study

- 12 anterior cervical discectomy and fusion (ACDF)
- 4 neurosurgeons (Intermediate and experts)
- 11 SN (Intermediate and experts)
- 2 coders
- Familiarity: 1 - 5 surgeries together in the last 6 months



10% of surgical time

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Non Technical Skills in Robotic Surgery

Review of Literature

Observations + Interviews

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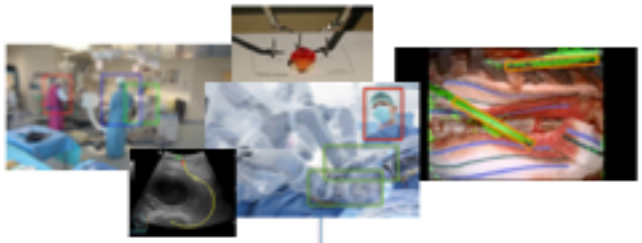
Situation Awareness



Situation recognition

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Assistance
Decision support systems
Automation
OR Management Optimization
Training/Evaluation
Traceability - QC
Learning
Assessment

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Institut Thématique Multi-Organismes
Technologies pour la santé
Bloc Chirurgical du Futur :
Réalité virtuelle, Robotique et
Science des Données Chirurgicales
Pierre Jannin
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11ème journée ITS – 2 & 3 octobre 2019 – Rennes – https://its.aviesan.fr

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