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Development of a Robotic Driven Handheld Laparoscopic Instrument for Non-Invasive Intraoperative Detection of Small Endoluminal Digestive Tumors

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Highlights

This paperwork introduces a

which aims achieving:

in the process of:

A prototype of the experimental developed instrument is shown within this presentation

Agenda

- Actual context
- Available surgical procedures & constraints
- Problem statement & proposed solution
- Framework methodology
- Developed instrument
- Conclusions

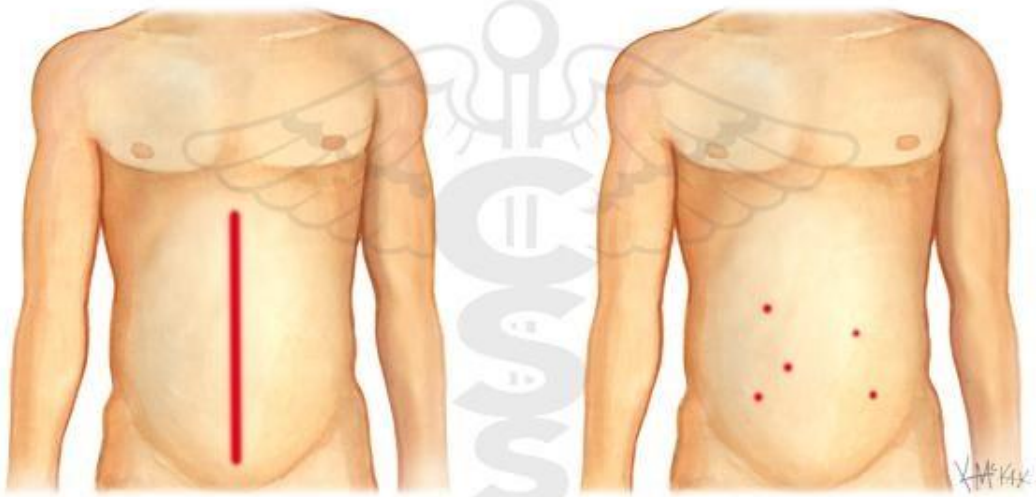
Context

together with

generated an

for identification of :

Available procedures & limitations

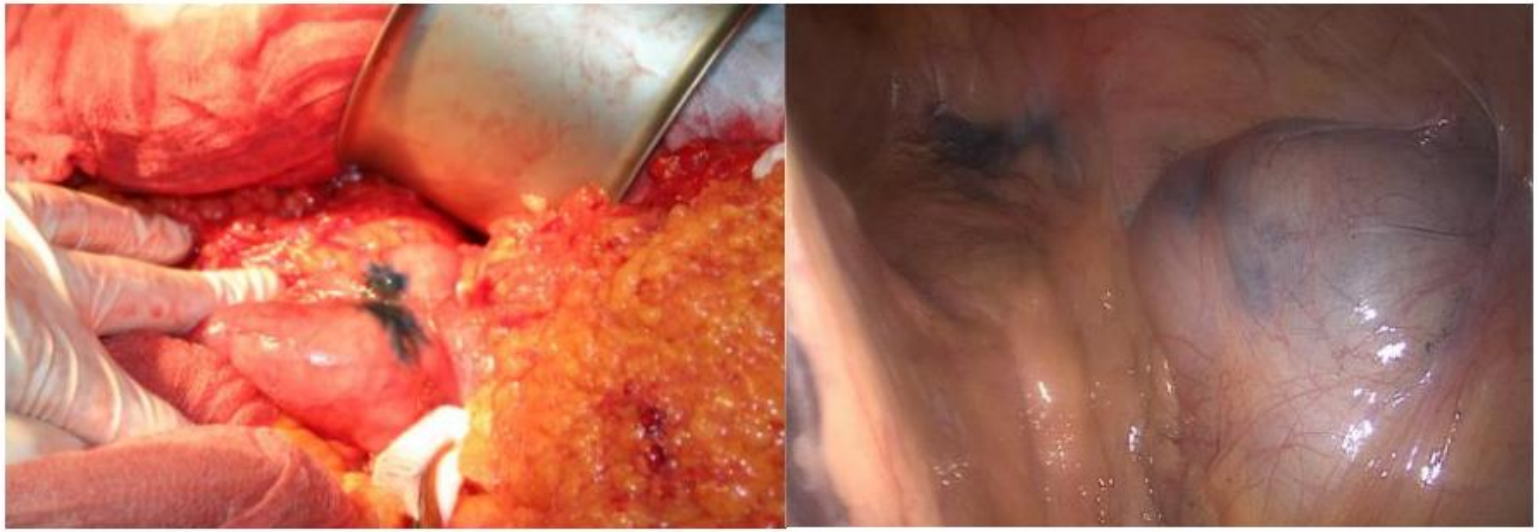


Open surgery Laparoscopy

Traditional open surgery

MIS Laparoscopy - practices

- ↑ endoscopist not required during surgery.
- ↓ needle gets contaminated, patient experienced abdominal pain.
- ↓ injected dye colors proximity tissues.



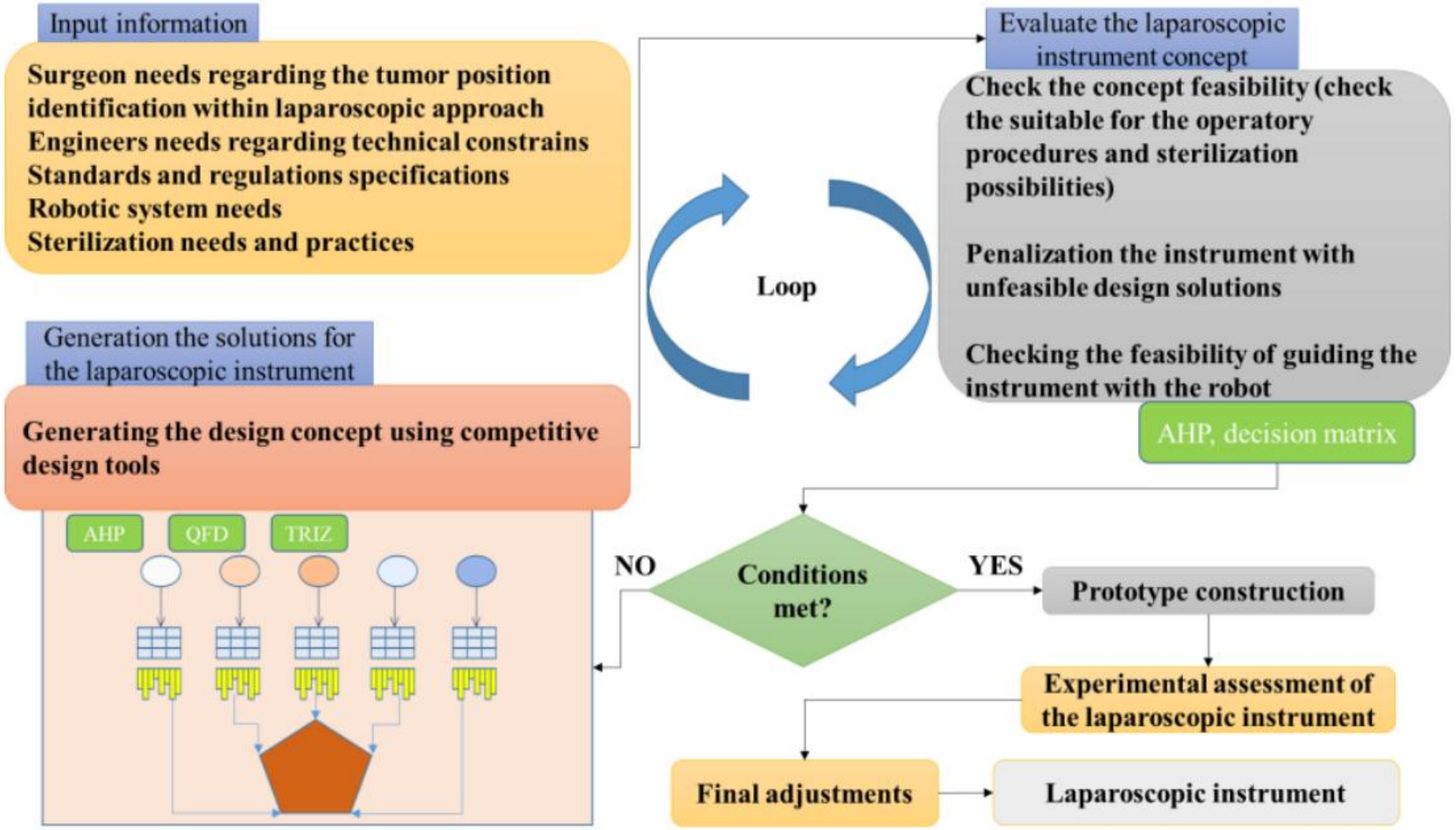
MIS Laparoscopy - practices

- endoscopist and logistics are required at surgery time.
- reduced working space due to insuflation of gas into the lumen of stomach or colon resulting in a distention of the bowel.

Problem statement

Proposed solution

Methodology – design framework



Methodology – target functions (TF)

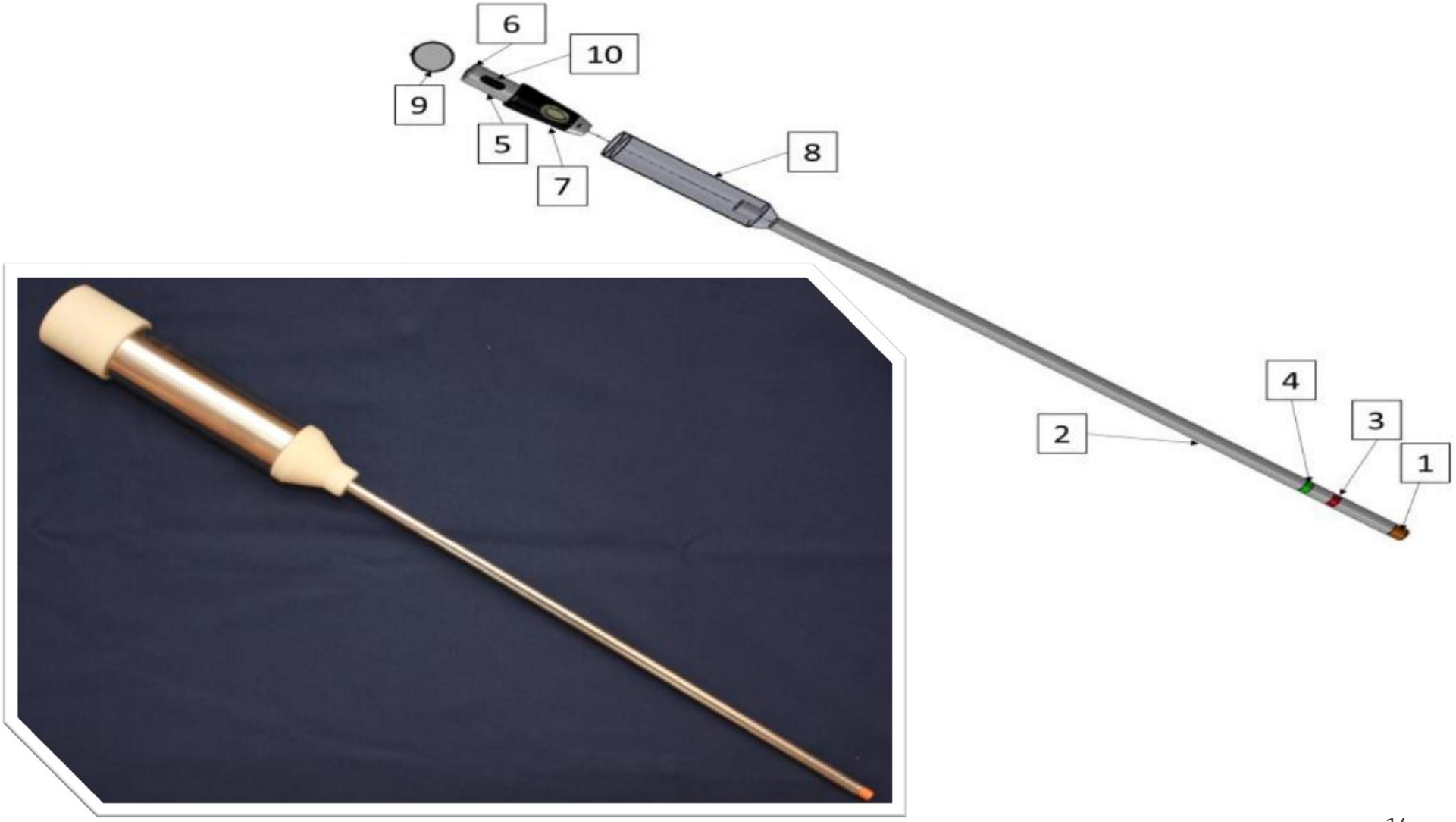
TF1: High quality						
TF2: Affordable costs						--
TF3: High efficiency					++	++
TF4: High precision				-	++	++
TF5: Easy to handle by surgeon & robot			++	++	++	++
Optimization trend			↑	↑	↑	↓	↑
Requirements	Importance	TF5	TF4	TF3	TF2	TF1
MR1: sterilization by standard methods	10%		*		o	o
MR2: usage in laparoscopic and classic procedures	25%	*	*	o	o	
MR3: Identification of tumors extremely accurate	65%	●	●	●		●
Value weight [%]		24.0	25.9	23.6	8.1	18.4

Methodology – solving TF conflicts

1. Cost minimization vs. high quality
2. Increasing efficiency vs. precision

1. Change density or physical state, make immovable parts movable; Use composite materials, etc.
2. Replace mechanical means with sensory means, use electric, magnetic fields to interact with object, etc.

Instrument – design & prototype



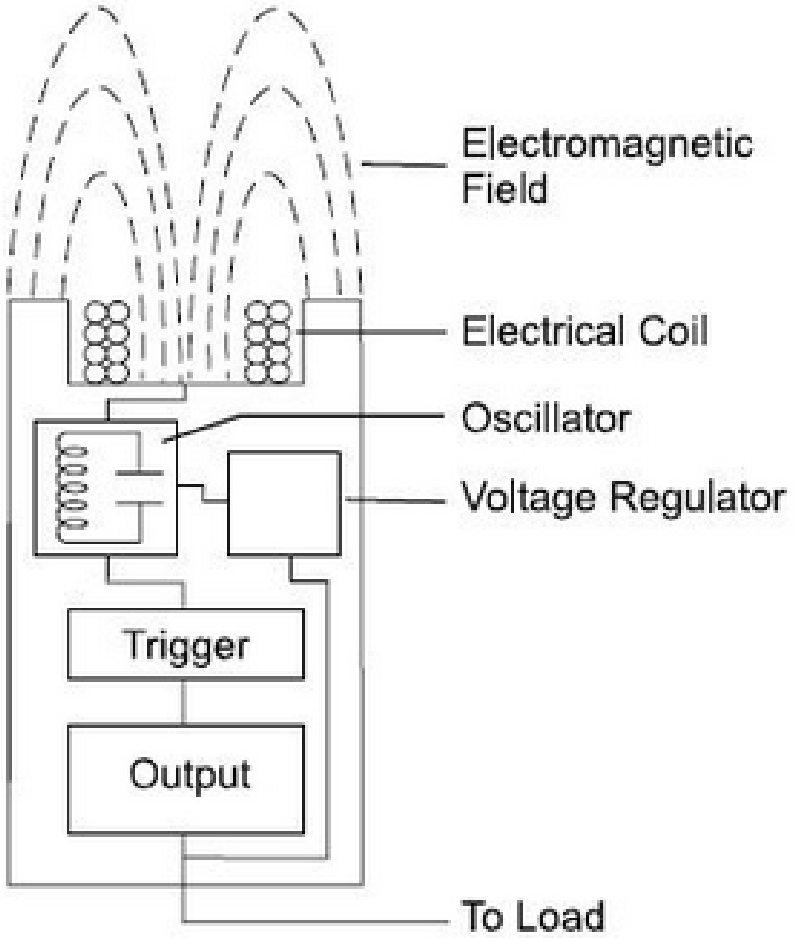
Instrument – sensing element

Sensor used:

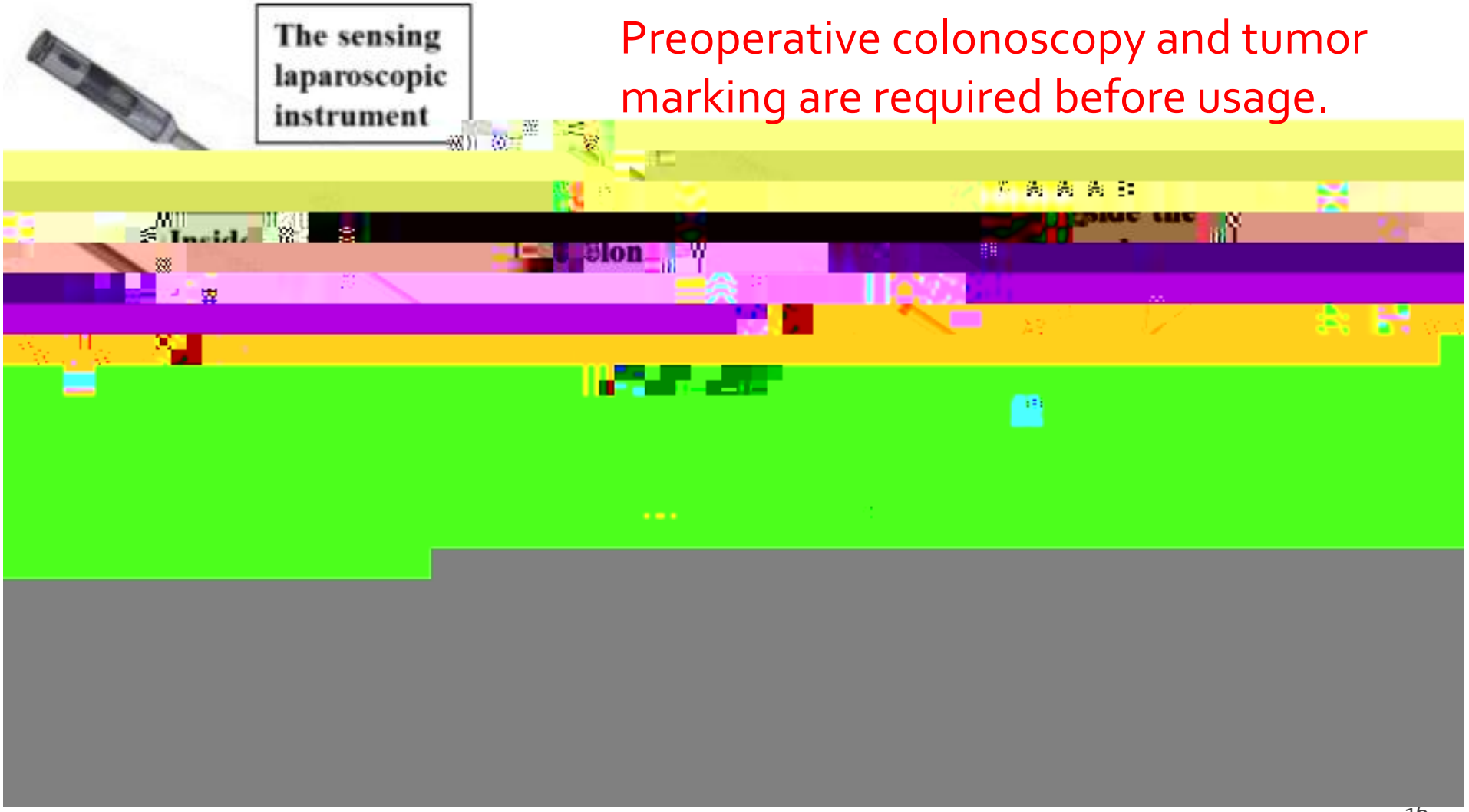
- IFM IE5352

Sensor characteristics:

- Operating voltage: 10-30 VDC
- M8 body size.
- Normal open transistor output
- Non-flushable



Instrument – usage example



Preoperative colonoscopy and tumor marking are required before usage.

Instrument – usage & testing

a) handled by a surgeon

b) handled by a robotic system

Instrument – experiment

Within a bowel wall of 20 cm tumor marking clips were applied.

Each marking elements were applied with a Karl Stroz applier.

- Evaluate detection accuracy at different:
  - Motion curves
  - Orientations angle
  - Velocity

Instrument – validation

titanium	steal ϕ 0.4 mm	cooper ϕ 0.3 mm	cooper ϕ 0.5 mm	Stain. steal ϕ 0.2 mm	Stain. steal ϕ 0.4 mm
					
60% at 1.15mm	85% at 2.9 mm	70 % at 2.0 mm	75 % at 2.4 mm	80 % at 2.5 mm	85 % at 3.5 mm

Conclusions

- A methodology for concurrent planning and design of surgery products considering both medical and performance requirements is introduced.
- Developed laparoscopic sensing instrument is adaptable to be used in both open and laparoscopic surgery.
- At this stage the instrument can be used by surgeon or by a guided industrial robot system.

Questions?

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