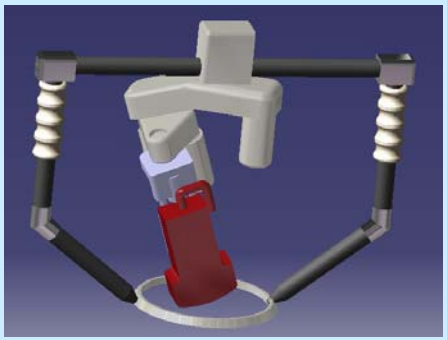
Towards a methodology of medical robot design



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Design of medical robots

Medical Requirements

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Medical gesture analysis

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Specifications chart

robotics constraints
specific needs

Classification robots

morphologies
medical domains

↓ Designer helping tool

Topological synthesis

choice of morphologies

↓

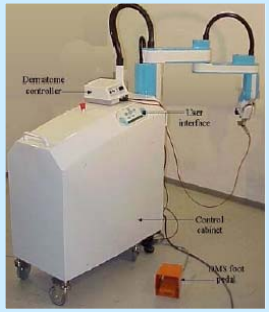
Dimensional synthesis

robots dimensions
choice of actuators

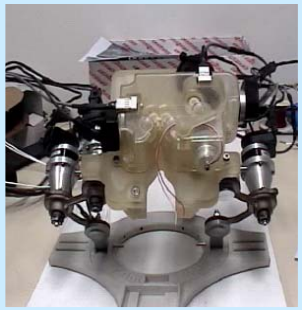
1- Study of specifications

Otelo 2

TER



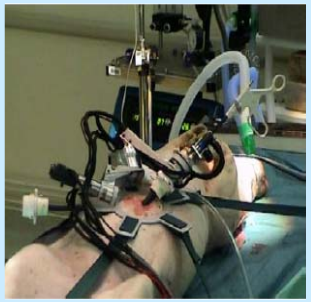
Dermarob



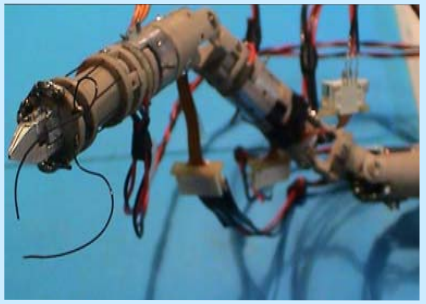
CT-Bot

Hippocrate

Padyc



MC2E



Drimis

1- Study of specifications

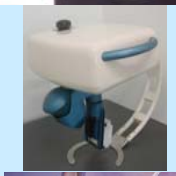
Medical gesture follow up		safety conditions
Continue path planing without collision Spherical movement around point contact probe skin Inclination 35° mini, 60° Maxi Movement tangent to skin cercle R= 25mm Translation perpendicular to skin -30mm to 10 mm Own rotation over than 90°		Dimensions : inaccessible safety zone Low powered actuators Robot quickly removed from patient Minimum number of dof Easily controllable structure
Implementation	Max Speed	Max Strength
Mobility Light weight Compact Fast implementation Interchanging probes	v = 30 mm/s ω = 0,5 rad/s	Fz = 20 N

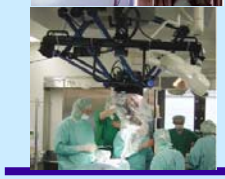
Specifications chart of Otelo 2 : tele-echography robot

2- Classification of medicals robots

- 60 medical robots classified by : medical fields, mechanical structure, number of degree of freedom, kinematic configurations



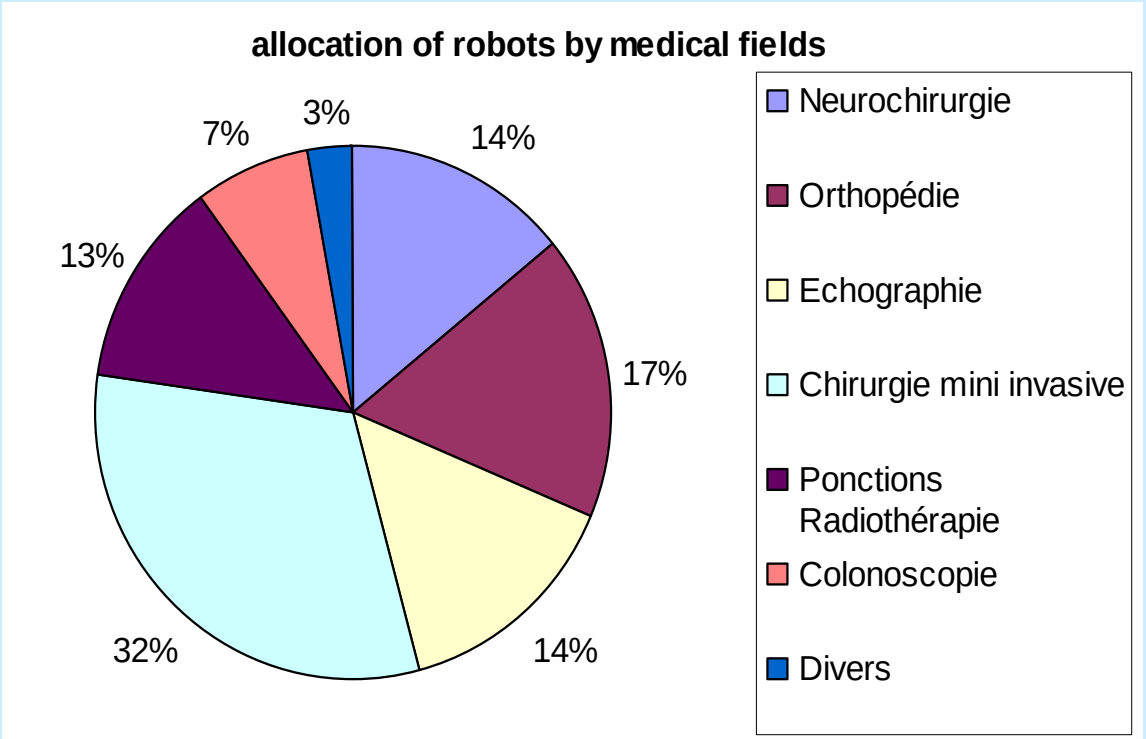





Laboratoire	Robots	Cinématique	archi globale	Porteur	Poignet	ddl	config globale
Acrobot Ltd Imperial College	Acrobot	anthropomorphe	s	s		6	6R
Computer Motion	Aesop	Scara RCM passif	s	s	RCM	6	PRRRRR
Madhani	Black Falcon	RCM	s		RCM	8	RRPRRRRP
Ortomaquet	Caspar	anthropomorphe	s	s		6	6R
Brandt Zimolong	Crigos	parallèle Stewart	p	p		6	
LSIIT	CT-Bot	parallèle	p			5	RP
LIRMM	D2M2	bras passif	s	s	s	5	PRRRP
Intuitive Surgical	Da vinci	RCM actif parallélogramme	s	s	RCM	6	RRPRRR
LIRMM	Dermarob	Scara	s	s		6	PRRRRP
LRP	DRIMIS	Outil intra -corporel	s		s	5	RRRRR
Masuda	Echographie abdomen	hybride	h	p	RCM	6	RRRRRP
Salcudean	Echographie artérielle	Série	s	s	RCM	6	PRRRRR
Wendlandt	Endo - plateforme	parallèle Stewart	p		p	3	PPR
Armstrong Healthcare	EndoAssist	RCM passif	s	s	RCM	5	PRRRR
Imperial college	EndoBot	RCM actif	s			4	RRRP
LIRM	Hippocrate	anthropomorphe	s	s		6	6R
TIMC	LER	RCM actif poignet sphérique	s		RCM	3	RRP
Israël Shoham Burman	MARS	parallèle Stewart	p		p	6	
LRP	MC2E	RCM actif poignet sphérique	s		RCM	4	RRRP
TIMC	Neuromate	anthropomorphe	s	s		6	RRRRRRR
LVR	Otelo	RCM actif	s		RCM	6	PPRRRP
TIMC	PADyC ou RSP	Scara passif	s	s	s	6	PRRRRP
Etats Unis	PAKY	RCM poulie courroie bras passif	s		RCM	7	RRP
Finlay Armstrong Healthcare	Path Finder	anthropomorphe bras passif	s	s		6	6R
ISS	Robodoc	Scara actif	s	s		5	RRPRR
Auer Imperial College	Roboscope	parallèle	p	p		6	
TIMC	RPL	hybride	h	p	RCM	4	PPRRP
Berkeley San Francisco	RTW	Hybride	h		RCM	6	RRRPRP
Mitsuishi	RUDS	Série cartésien	s			7	PPPRRRP
Isis Robotics	Surgiscope	parallèle delta+Rm	p	p		3	
Vilchis	TER 2	hybride	h	p	RCM	6	PPRRRP
LVR	Teresa	RCM actif	s		RCM	4	RRRP
Polytec PI URS	URS Evolution1	parallèle Stewart	p	p		6	6(SPS)
Computer Motion	Zeus	Scara RCM passif	s	s	RCM	4	PRRR

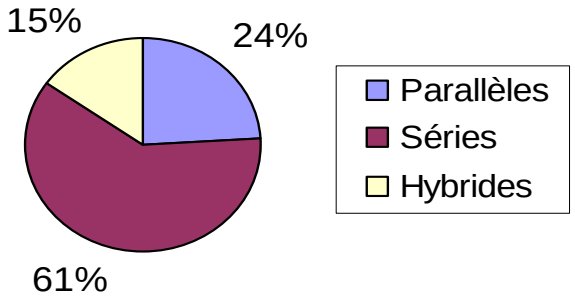
2- Classification of medicals robots

- statistic analysis



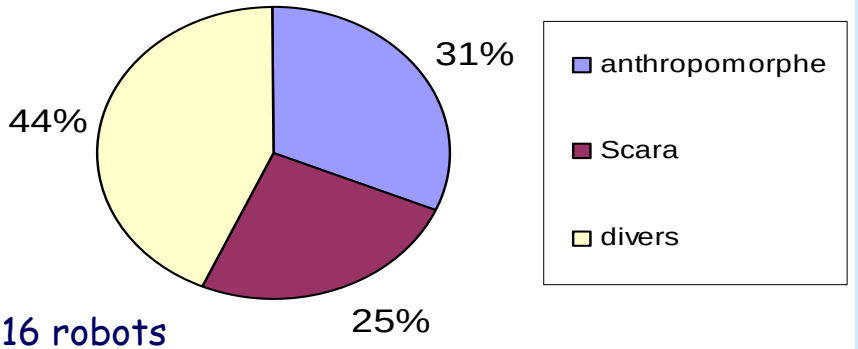
2- Classification of medicals robots

allocation of structures



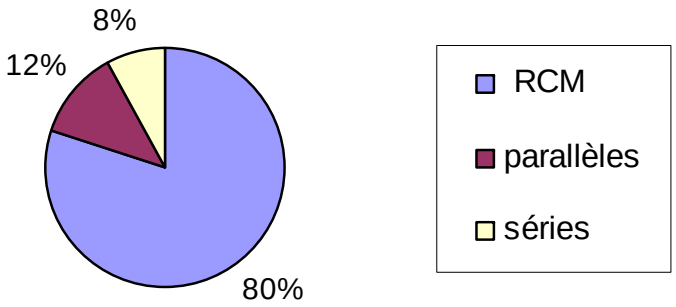
33 robots

allocation of serial carriers



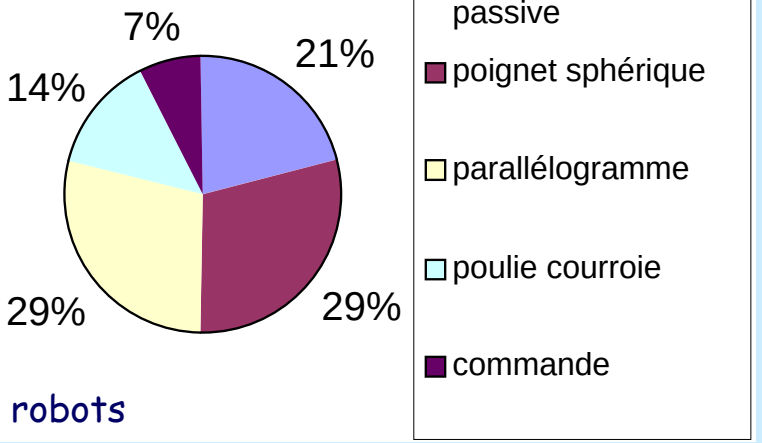
16 robots

allocation of wrists



25 robots

Design of RCM robots



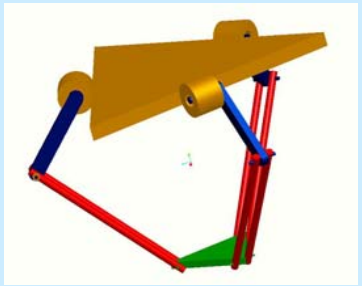
14 robots

3- Designer helping tool

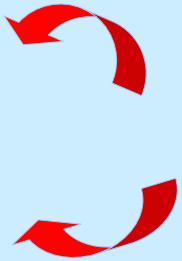
$$(d < 500^3 mm^3 + w < 5\,kg) \cdot (a < 1\,mm) \Rightarrow Parallel$$

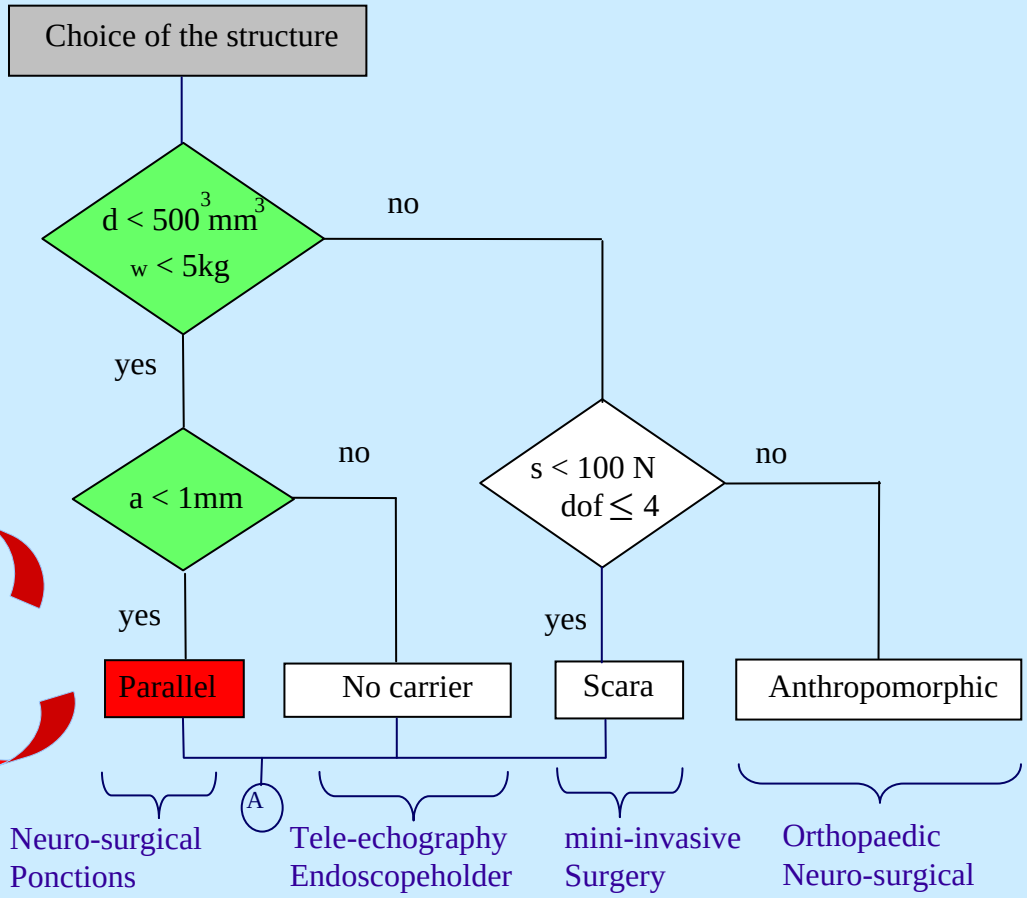
d : dimensions
w : weight
a : accuracy
s : strength
dof : degree of freedom
Ⓐ Choice of wrist

Delta



Hexapode

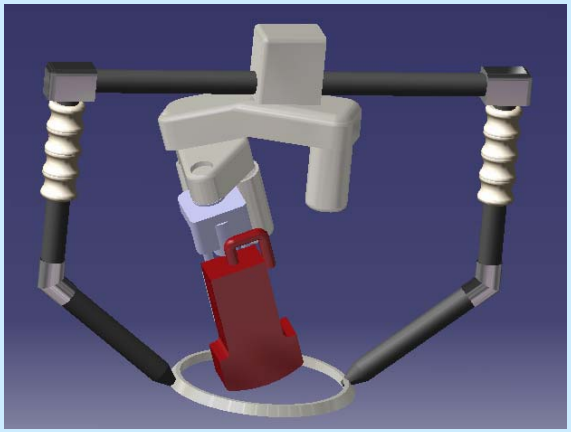


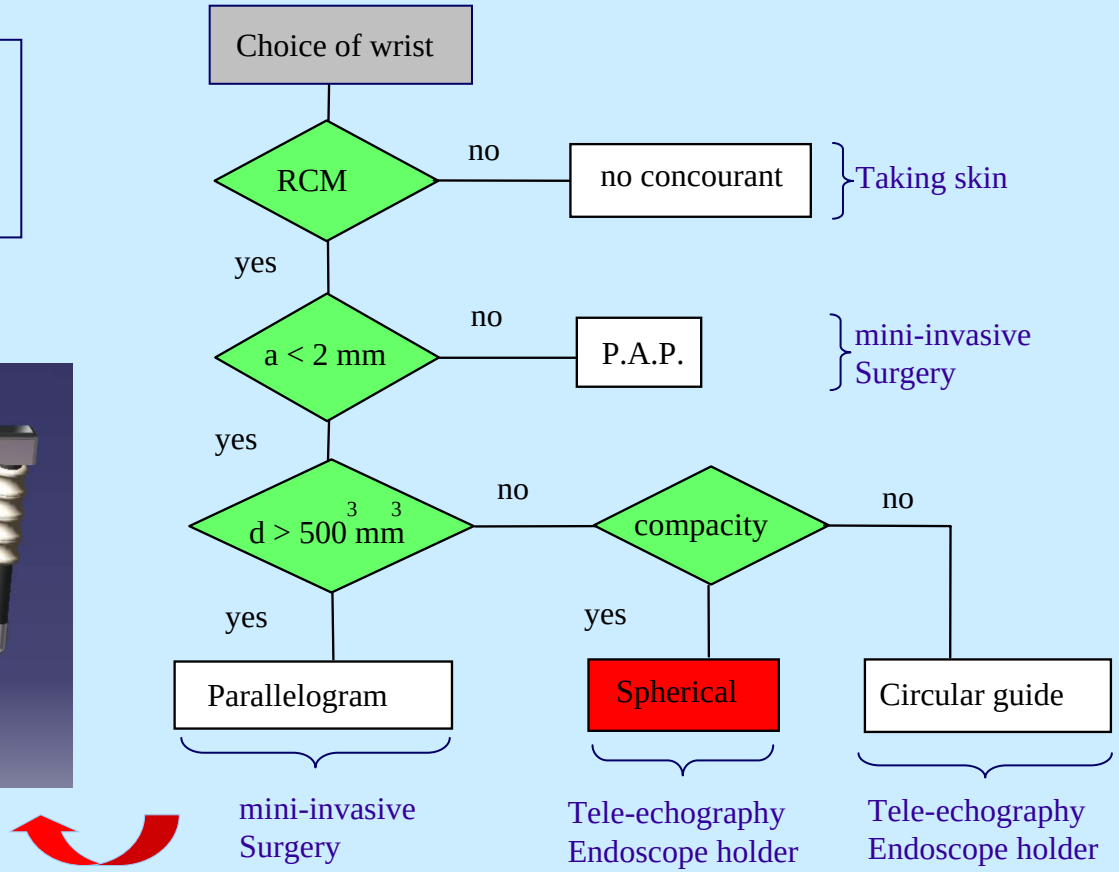


3- Designer helping tool

$$(RCM \cdot a < 2\ mm) \cdot \overline{(d > 500^3\ mm^3)} \cdot compacity \Rightarrow spherical\ wrist$$

d : dimensions
RCM : Remote Center Motion
a : accuracy





4- Conclusion and Perspectives

To conclude :

- Specifications ⇨ design constraints and criteria
- classification ⇨ knowledge of the design of medical robots

- Designer helping tool by a case-based design (CBD) method

permits choosing morphologies

The flow charts are verified by 51 robots of the classification

The other robots are either particular cases or we don't have all the necessary information about them

4- Conclusion and Perspectives

It is planned to :

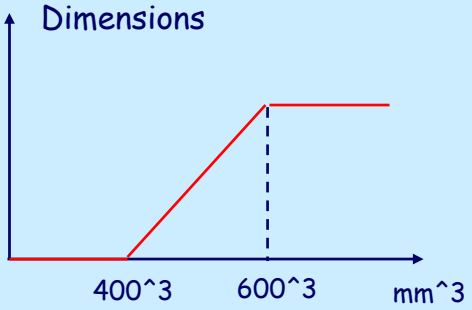
- improve the bounds of the flow charts :

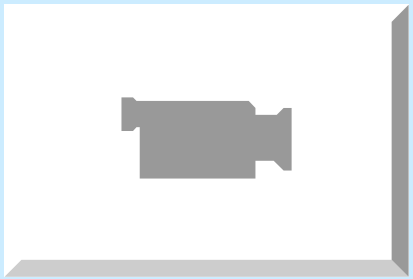
  perhaps by using fuzzy logic ?

- link the flow charts with computer assisted design

- create a web site presenting all existing solutions

- make a dimensional analysis applied to a new medical robot





⇨ generic methodology of medical robot design