中华人民共和国科学技术部
Ministry of Science and Technology of the People's Republic of China

国立研究開発法人 科学技術振興機構

SAKURA SCIENCE 樱花科技计划

Applied Research on Robotic Aided Surgery

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July 20,2017

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http://robolab.sjtu.edu.cn

Contents

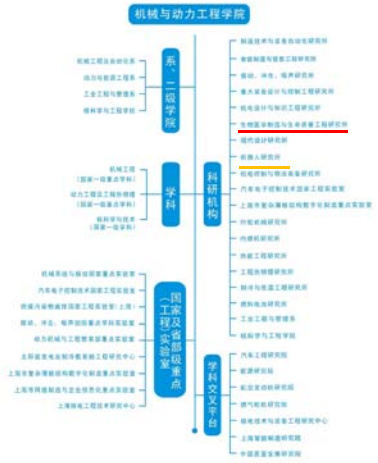
机械与动力工程学院
School of Mechanical Engineering, Shanghai Jiao Tong University

学院位于上海交通大学闵行校区（主校区），南临黄浦江，毗邻国家级高新技术园区—紫竹科学园。

学生规模
- 学生总数：约5000人
- 博 士 生：160/年
- 工学硕士：430/年
- 工程硕士：450/年
- 本 科 生：430/年

教师队伍
- 教职工数：430人
- 教　　师：330人
- 正 高 职：123人
- 副 高 职：132人
- 中级职称： 75人

学院楼群
- 总面积：5.2万平方米
- 教师办公大楼
- 先进制造大楼
- 热动基地大楼
- 汽车工程大楼



机械与动力工程学院上溯于1913年上海工业专门学校设立的电气机械科，是上海交通大学历史最悠久的院系之一。在机械与动力工程学院的发展史上，创造了许多中国第一：中国最早的内燃机、第一台自动扶梯等等。更为引以自豪的是，新中国的第一艘万吨轮，第一艘核潜艇、第一颗原子弹、第一枚运载火箭、第一颗人造卫星、第一架超音速民航客机……许多都是在学院校友的主持和直接参与下完成的，在1999年国务院表彰的两弹一星功臣中，钱学森、王希季等均毕业于机械与动力工程学院。改革开放以来，机械与动力工程学院以创建世界知名学院为奋斗目标，综合实力得到快速提升。

百年历史，英才辈出

学院创立于1913年，培养了14000+ 校友

- 50余名两院院士，一批杰出的科学家、教育家、实业家和政治家；包括两弹一星元勋钱学森、王希季等
- 许多院友成为现代中国工业的先驱，在航天、航空、能源、制造装备、潜艇、燃气轮机等行业做出杰出贡献

百年学科庆典
（北京人民大会堂）

百年院庆

数说机动学院这十年------学科建设

1st 在教育部一级学科评估中，机械工程学科连续两次居**全国之首**，动力工程及工程热物理学科名列第三，核科学与技术排名第五。

2 新增国家自然科学基金委**创新群体 2 个**：

- “复杂装备的数字化设计”
- “传热传质与高效热力系统的基础研究”

“复杂装备的数字化设计”获得国家自然科学基金委员会的Ⅲ期延续资助，是学校首个资助期为9年的创新群体。

数说机动学院这十年------一流师资队伍

3 十年间，学院新增**3名**中国工程院院士、中国科学院院士。新增千人计划教授13人，长江学者教授9人，国家杰出青年基金获得者6人，优秀青年基金获得者6人。
学院现有教师330人，其中正高职123人。

学院人才计划清单

两院院士	6人	长江学者特聘/讲座教授	18人
千人计划	13人	青年千人	5人
973首席科学家	6人	上海千人	8人
杰出青年基金获得者	14人	青年拔尖人才	1人
基金委创新群体	2个	优秀青年基金获得者	6人
教学名师	4人	新世纪百千万人才工程	7人
市科技精英、领军人才	5人	何梁何利	3人

数说机动学院这十年------实验室建设

4 **4个国家级重点实验室**：

- 机械系统与振动国家重点实验室
- 汽车电子控制技术国家工程实验室、
- 燃煤污染物减排国家工程实验室（上海）
- 振动冲击噪声国防重点学科实验室

5个省部级重点（工程）实验室和工程中心	6个学科交叉平台
动力机械与工程教育部重点实验室	能源研究院
太阳能发电与制冷教育部工程研究中心	汽车工程研究院
上海市复杂薄板结构数字化制造重点实验室	燃气轮机研究院
上海市网络制造与企业信息化重点实验室	航空发动机研究院
上海核电工程技术研究中心	核电技术与装备工程研究中心
	上海智能制造研究院

数说机动学院这十年------科研经费与成果

5亿 2015年科研经费增长至近5亿，比2006年增长了200%。十年间，学院以第一完成单位获得国家、省部级奖89项

近十年学院国家科学技术奖获奖

一、国家自然科学二等奖	
·纳微尺度流体流动与传热传质的基础研究	郑　平 等
·并联机器人机构拓扑与尺度设计理论	高　峰 等
·燃料设计理论及其控制内燃机燃烧与排放的基础研究	黄　震 等
·吸附式制冷的吸附机理、循环构建及热设计理论	王如竹 等
二、国家技术发明二等奖	
·太阳能空调与高效供热装置与应用	王如竹 等
三、国家科技进步二等奖	
·工业机器人作业系统的关键技术研究、开发与应用	丁　汉 等
·高性能尾气净化器柔性制造关键技术及成套装备	刘成良 等
·复杂薄板产品装配的数字化工艺设计与装备技术	林忠钦 等

数说机动学院这十年------国际化办学

30&30% 与美国密西根大学、普渡大学、卡尔斯鲁厄大学等近30所学校进行高水平合作办学，通过设置全英文课程、引进先进课程体系，实施不同类型留学形式（学位生、交流交换生、海外实习生等），比例达30%。

近十年，4300多人次赴海外参加各类学术交流活动，开展各类国际合作研究近550项。

学院近五年接收学位留学生113人，交流生294人。

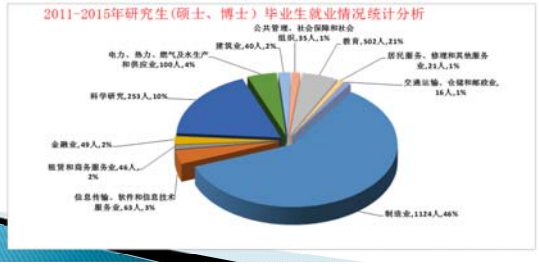
研究生国际合作培养学校分布：

与世界近30所著名大学建立了研究生合作培养计划。

实施硕博联合培养，学分与学位互认、联合授予学位。

职业规划与就业：

- 2015届研究生就业率99.6%，就业领域专业对口率93.1%；
- 建设国家级实习实践基地16个，就业实习合作单位200余家；
- 每年国家重点行业、大型央企集团、世界500强外企专场招聘会60余场；
- 开展全程、多维职业规划教育，聘请央企及世界500强企业人力资源高管担任学生职业生涯导师；
- 研究生就业能力和就业质量全国领先，机械与动力工程学院在全校30个院系中，近6年中5次获得全校唯一的就业质量特等奖



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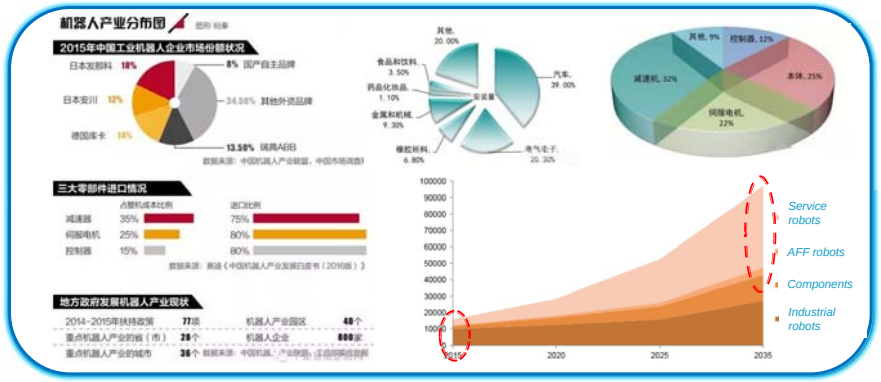
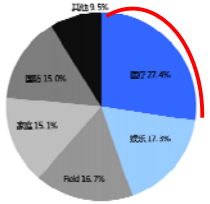
1.背　景 Background

Chinese annual sales of robots is running first in the world for four consecutive years
Governments and departments are putting the robot industry development first place

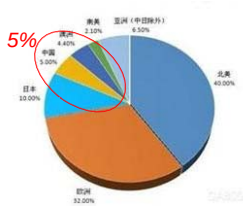


1.背　景 Background

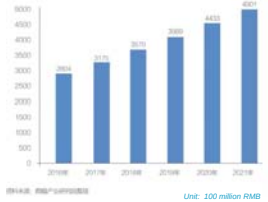
Service robot world market share in 2013



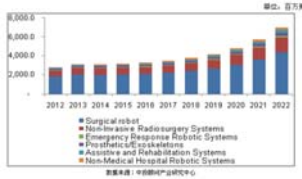
Medical robot national market share in 2013

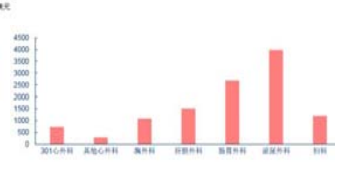


Medical instruments industrial value form 2016 to 2021



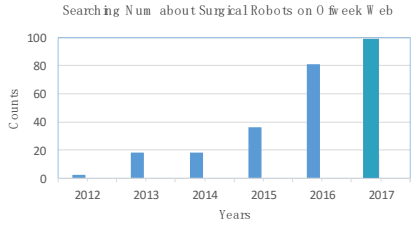
Medical robot market chart



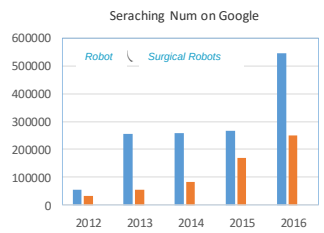


1.背　景 Background

Searching Num about Surgical Robots on Oneweek Web



Seraching Num on Google



Increasing demand for minimally invasive diagnosis and treatment procedures, growth of the elderly population, deterioration of the global environment, unhealthy eating habits and the unhealthy lifestyles, alcohol consumption, and the lack of physical exercise on the urban population, all these factors have greatly increased the incidence of surgery; thus surgical robots will be another big share in robot market cake besides industrial robot.

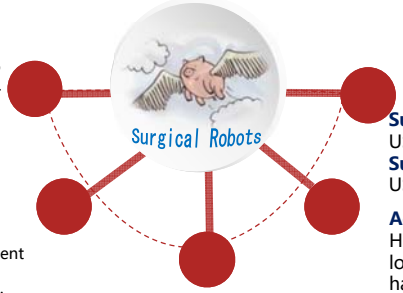
1.背　景 Background

The health care market will exceed 10 trillion by 2020:

annual growth rate is over 20% for medical equipment and over 30% for surgical robots

Bull market for medical industry in next 15 years

- Hospital privatization
- Hospital independency
- Population aging
- Diagnosis and treatment decentralization
- Telemedicine popularization
- Medical instruments intelligentization
- Product localization



"Health China 2030"

Chinese healthy development guideline for the next 15 years

Medical instruments：Medicine

China： 1:3
Developed Countries 1:1

Surgical Navigation：
USA 4000sets China 150sets

Surgical Robots：
USA 3000sets China 62sets

Advantages：
Higher precision, less blood loss, avoid damage from hand shake, better safety for both doctor and patients, higher surgical efficiency, less workload etc.

2016-2020 China Medical robot industry depth research and investment prospects report from CIC said that, the global medical robot industry annual revenue had reached 7.47 billion US dollars by January 2016, and is expected to be stable with compound annual growth rate of 15.4% in 5 years; the market size of the global medical robot is expected to reach $ 11.4 billion by 2020. Among them, surgical robots accounted for about 60% market share. Medical robot market focus will be gradually transferred from North America to Asia, and China's industrial development can be worth expecting.

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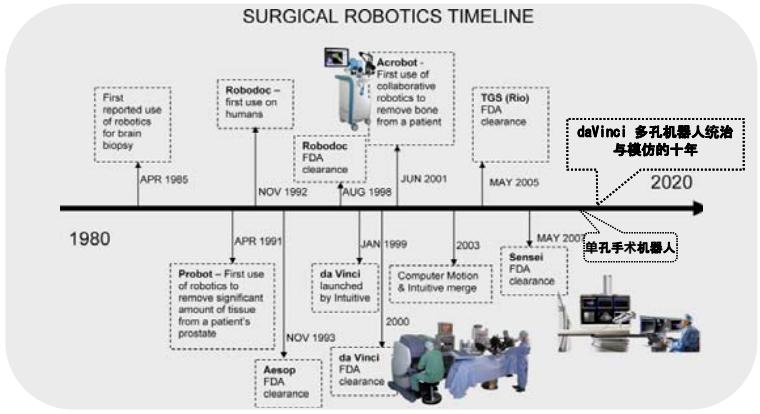
2.動　向 Development tendency



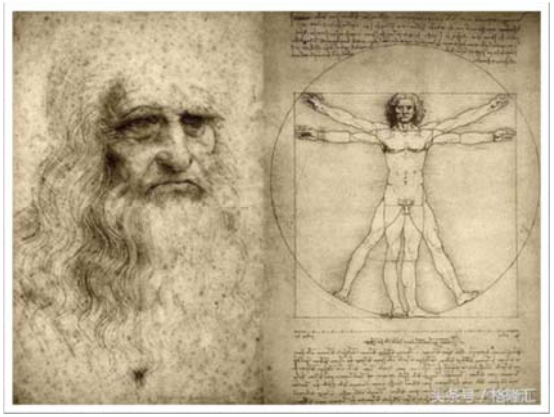
Surgical robotics: Reviewing the past, analysing the presentImagining the future
Paula Gomes Cambridge Consultants, Science Park, Milton Road, Cambridge CB4 0DW, UK

Surgical robotics Timeline

2.動　向 Development tendency

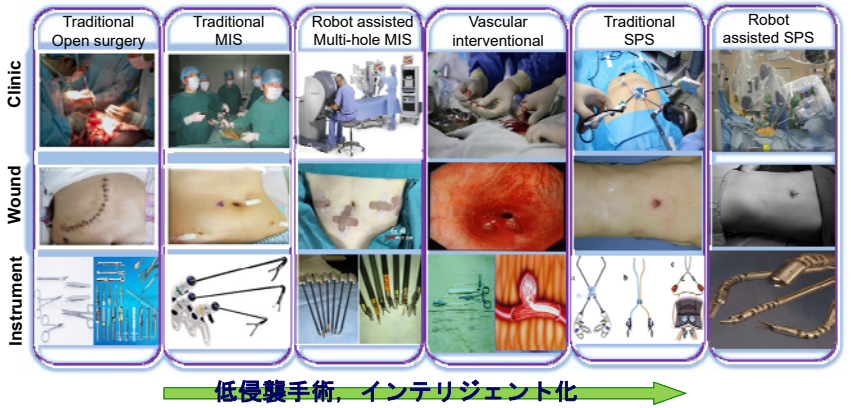
In 1985, Puma 560 industrial robot was used to try to assist in brain biopsy in UAS, which could control neurosurgical biopsy accurately. Itis the initial prototype of the surgical robot and exploration. In 1988, Puma 560 was used in prostate surgery, and it contributed to the emergence of PROBOT, which was a system specifically designed for prostate surgery. It is the first surgical robot to be used exclusively for surgery.

2.動　向 Development tendency



The technology of the DaVinci Surgical Robot was derived from the Stanford Institute (SRI) with the official background. At the end of the 1980s, a group of scientists started the R&D of the surgical robots at the Stanford Institute, which was intended to develop a robot for battlefield. The real name of the DaVinci Surgical Robot should be "Endoscopic Surgical Instrument Control System", and is the most successful and widely used surgical robot in the world.

2. 发展趋势 Development tendency



2.動　向 Development tendency

	传统开放手术	传统腹腔镜手术	机器人辅助手术
眼手协调	自然的眼手协调	眼手协调降低，视觉范围和操作器械的手不再同一个方向	图像和控制手柄在同一个方向，符合自然的眼手协调
手术控制	术者直接控制手术的视野，但不精细，有时受限制	术者须和持镜的助手配合，才能看到自己想看的视野	术者自行调整镜头，直接看到想看的视野
成像技术	直视三维立体图像，但细微结构难以看清	二维平面图像，分辨率不够高，图像易失真	直视三维立体高清图像，放大10~15倍，比人眼更清晰
灵活性和精准程度	用手指和手腕控制器械，直观、灵活，但有时达不到理想的精度	器械只有4个自由度，不如人手灵活、精确	仿真手腕器械有7个自由度，比人手更灵活、准确
器械控制	直观的同向控制	套管逆转器械的动作，医生需反向操作器械	器械完全模仿术者的动作，直观的同向控制
稳定性	人手存在自然的颤抖	套管通过器械放大了人手的震颤微创，术后恢复较快	控制器自动滤除震颤，比人手稳定
创伤性	创伤较大，术后恢复慢	微创，术后恢复较快	微创，术后恢复较快
安全性	常规的手术风险	常规的手术风险外，存在一些机械故障的可能	常规的手术风险外，死机等机械故障的概率大于腔镜手术系统
术者姿势	术者站立完成手术	术者站立完成手术	术者采取坐姿，利于完成长时间、复杂的手术

http://news.sznews.com/content/2016-05/27/content_13417094.htm

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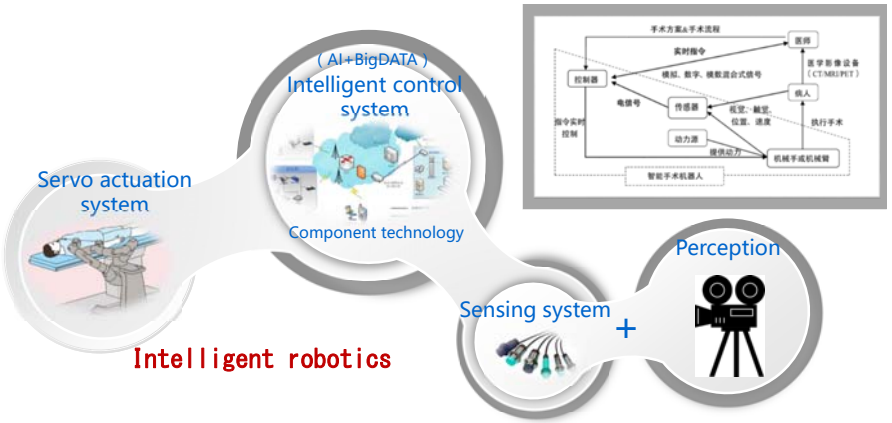
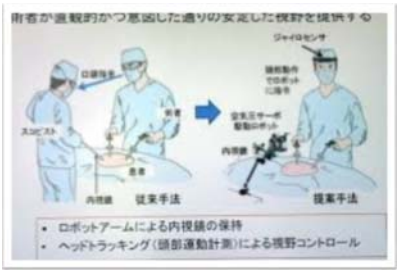
3.特　徵　Main characteristics



3.特　徵　Main characteristics



- MIS offers many advantages over the traditional surgery methods.
- The surgical robot is a cross-study of medicine, robotics, mechanics, biomechanics, computer technology and many other scientific research works, its ultimate goal is not to replace the surgeon, but work as an auxiliary tool to expand the doctor's surgical ability, improve the quality of surgery, and reduce the intensity of the doctor's work.

3.特　徵　Main characteristics

Computer Aided Surgery

Surgical Navigation

Tele-Operation

The tomographic image or 3D CG is displayed on the computer, and the scene of surgical site is displayed on the CG in real time during the operation. A more advanced technique that correctly overlaps the actual space observed by the physician with the virtual space information to construct an augmented realistic environment for the navigation of the surgical operation.

The three-dimensional construction information of the organ can be obtained by X-ray, MRI, CT and other measurement techniques, and the 3D model of the object can be established. Combine functional and anatomical information together with the model, the surgical integrated planning and navigation can be established with previous surgical simulations.

Surgical planning information can be used to assist the doctor to control mechanical system and the instruments for high-precision surgical operation and remote surgery. The teleoperation is not a simple physical separation, but also extend the physician's arms to regions that can not reached normally.

3.特　徵　Main characteristics

1 Application
- Navigation: Surgical instruments assistant positioning
- Treatment: Active surgical forceps; Master slave manipulators

2 Operation
- Passive: Surgeon's action restriction and correction
- Active: Generate active force to act

3 Control
- Preoperative planning: The 3D position data constituted by the preoperative image detects the lesion, guides the surgical instrument, or performs a resection
- Intraoperative operation: Auxiliary device for surgeon during operations

Contents

4.整形外科 Orthopaedic surgery

Traditional orthopedic surgery


Preoperative acquisition of X-rays


Preoperative planning


Artificial operation

Modern orthopedic surgery


Preoperative acquisition of X-rays


Surgical design


Intraoperative precise navigation, robot assisted precise medical care

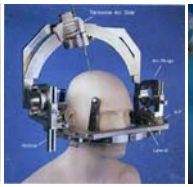
Future orthopedic surgery


Duplication


All three-dimensional visualization


Intelligent robotic assisted teleoperation

4.整形外科 Orthopaedic surgery

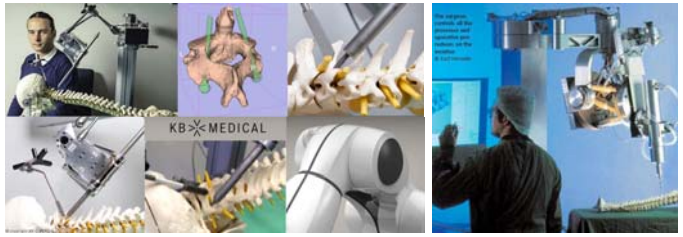



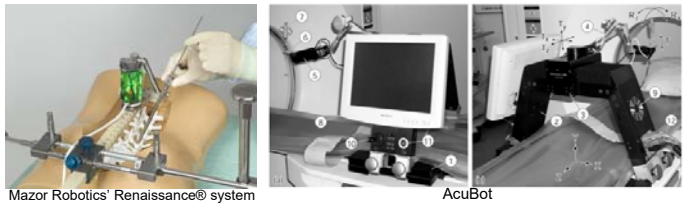



4.整形外科 Orthopaedic surgery

Prof.Qixin Cao's research team from SJTU, UEG Medical Group Ltd. and Shanghai Ninth People's Hospital together developed the Surgical Navigation and Planning Software

4.整形外科 Orthopaedic surgery





Mazor Robotics' Renaissance® system

AcuBot

4.整形外科 Orthopaedic surgery

SJTU Robolab V-I

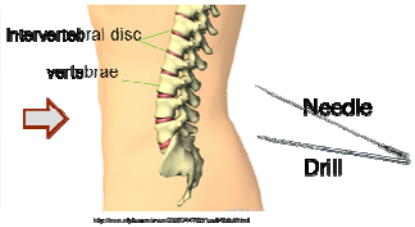
SJTU Robolab V-II

Prof.Qixin Cao's research team from SJTU, Fuer robot Ltd. and Shanghai First People's Hospital cooperated to develop the Spinal surgical robot system

4.整形外科 Orthopaedic surgery

- **Virtual assistant navigation** : Outside accessing pose adjustment is much limited by surgeon's judgement and determination, which may cause instability, inaccuracy and inefficiency for intraoperative robotic operations.

➢ Feasible and convenient method: Realtime virtual extended navigation lines along the instruments based on obtained CT images can greatly help the decision making process for surgeons.

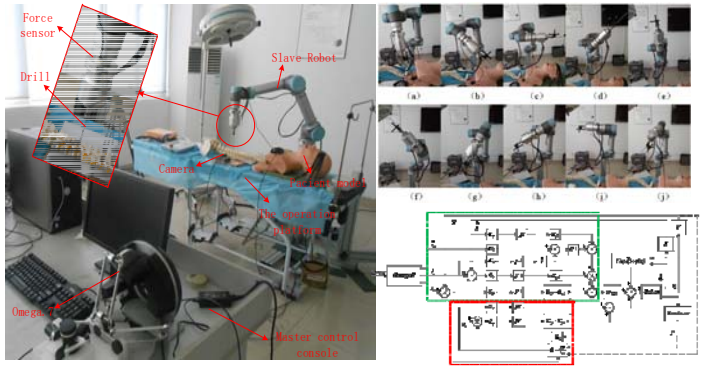


- Feasible/applicable
- Convenient
- Efficient

➢ Attracting ongoing method: Augmented reality (AR) based navigation will greatly help the decision making process for surgeons.

4.整形外科 Orthopaedic surgery

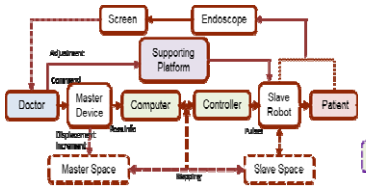
- Previous prototype for robotic assisted spinal surgery



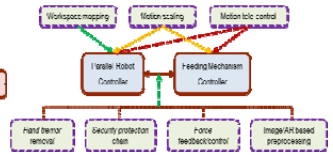
— W.Bai, Q.Cao et al. Force Control in a Robotic System for Spinal Surgery. ACCAS 2014

4.整形外科 Orthopaedic surgery

- Robotic assisted spinal MIS:
  improve precision, efficiency, safety, stability, ergonomics etc.
- Master-slave teleoperation:
  avoid radial damage, real time adjusting and accessing
- Specialized and miniatured design:
  clinic friendly, clinical applicable, easy to control and use
- Image processing & AR assisted:
  achieve advanced planning and guidance / navigation



Surgical robotic system architecture



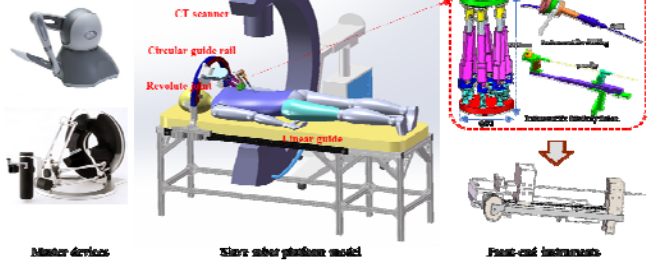
Robotic control algorithms scheme

4.整形外科 Orthopaedic surgery

- Master-Slave surgical robot system for spinal ablation surgery

6DOF parallel robot + 2DOF guide rail + 2DOF revolute joint + 1DOF instrument

intraoperative fine tele-adjustment | preoperative clinically extensive adjustment | surgical implement



Master devices | Slave robot platform model | Front-end instruments

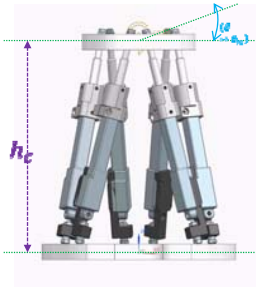
4.整形外科 Orthopaedic surgery

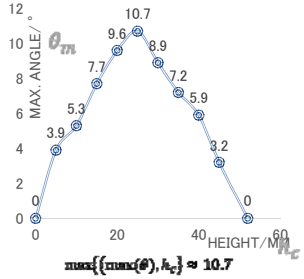
- Manipulability or dexterity of the parallel robot's moving plate varies as the height grows within its arrange, and shows a similar parabolic trend.

Method: miniatured parallel robot analysis

パラレルロボット

6サーボ電動パター



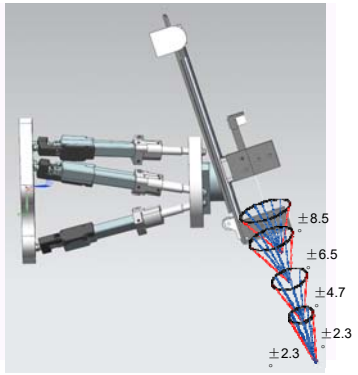


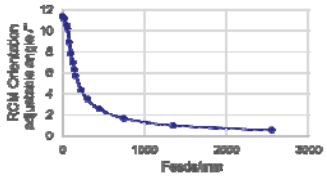
θ_m : the max. of the tilt angle (β) of the moving plate

h_c : the height or center distance between two plate's center

4.整形外科 Orthopaedic surgery

- Remote center of motion control for the front-end of the instrument, which is the most important procedure during the intraoperative teleoperation adjustment.





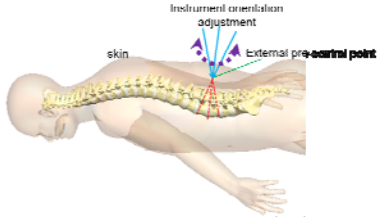
1.The miniatured parallel robot can just offer fine tuning for the end orientation of the needle.

2.The feeding or approaching process make the orientation adjustment more and more limited and difficult.

4.整形外科 Orthopaedic surgery

Method: virtual assistant navigation

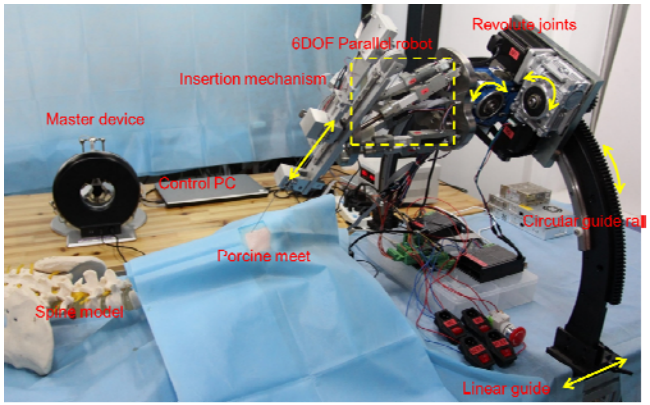
- Outside accessing pose adjustment is much limited by surgeon's judgement and determination, which may cause instability, inaccuracy and inefficiency for intraoperative robotic operations.
- Feasible and convenient method: Realtime virtual extended navigation lines along the instruments based on obtained CT images can greatly help the decision making process for surgeons.



- Feasible/applicable
- Convenient
- Efficient

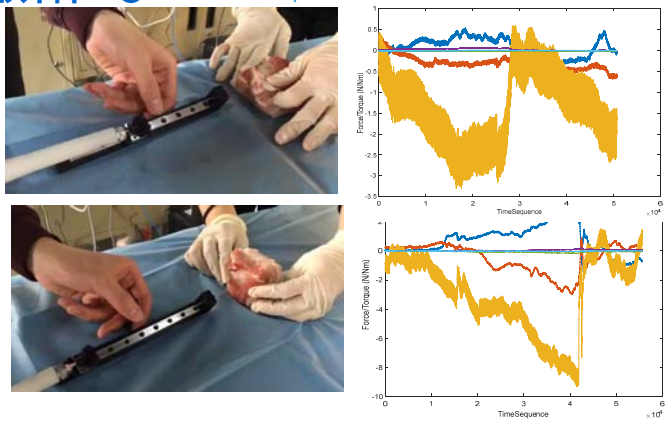
- Attracting ongoing method: Augmented reality (AR) based navigation will greatly help the decision making process for surgeons.

4.整形外科 Orthopaedic surgery



Spinal Surgery Robot System

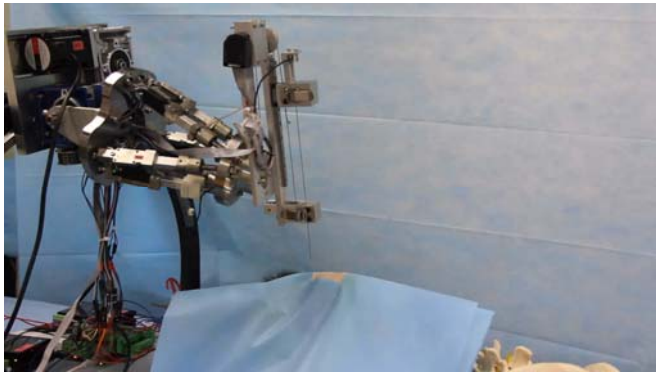
4.整形外科 Orthopaedic surgery



Clinically specialized robot system and experiments

4.整形外科 Orthopaedic surgery

Preoperative extensive adjustment + Intraoperative fine tele-adjustment + Surgical insertion



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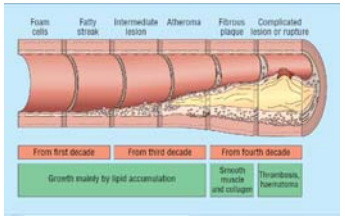
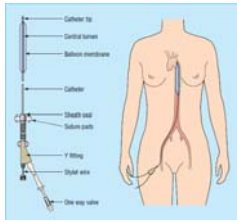
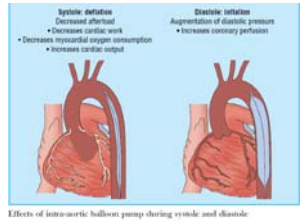
5.介入手術 Interventional surgery





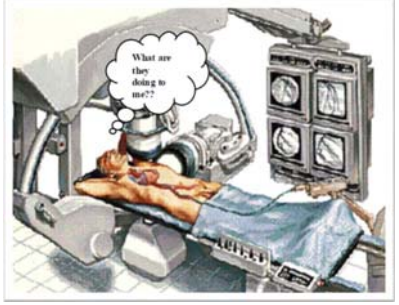


Effects of intra-aortic balloon pump during systole and diastole

Thrombosis is the formation of a blood clot inside a blood vessel, obstructing the flow of blood through the circulatory system. Interventional therapy uses modern high-tech means of a minimally invasive treatment, which guides wire and other sophisticated instruments like special catheter under the guidance of medical imaging equipment into the body and conducts body pathological diagnosis and local treatment.

5.介入手術 Interventional surgery

Robotic angiography system for 3D mapping of blood vessels during vascular surgery. (Courtesy of Siemens AG)



Intervention process are conducted under the guidance and supervision of imaging equipments, which enables accurately accessing to the lesion directly to the local, without large trauma. Thus advantages like accurate, safe, efficient, wide indications, fewer complications have make it the preferred treatment for many diseases.

5.介入手術 Interventional surgery

5.介入手術 Interventional surgery

5.介入手術 Interventional surgery

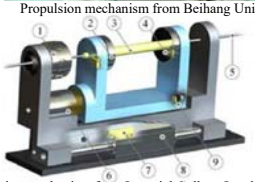
Cardiovascular minimally invasive interventional robotic system mainly includes catheter/guide wire propulsion mechanism, propulsion mechanism of the auxiliary positioning device and propulsion operating device. Propulsion mechanism is the core device for interventional robots.

Amigo Propulsion mechanism

Propulsion mechanism from Beihang Univ

Propulsion mechanism from HIT Univ

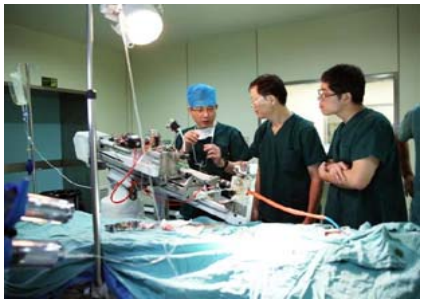
The Magellan Robotic System



Propulsion mechanism from Imperial College London

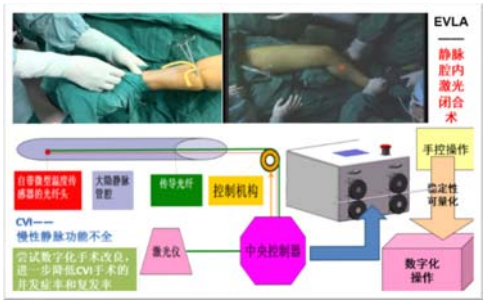
Propulsion mechanism from Kagawa Univ

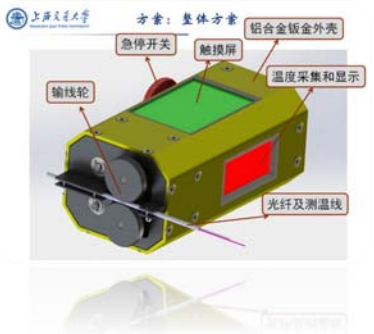
5.介入手術 Interventional surgery



Prof.Bo Yu's team from Fudan University Affiliated Pudong Hospital developed the domestic remote digital vascular interventional robot and completed animal total cerebral angiography successfully

5.介入手術 Interventional surgery





Prof.Qixin Cao's research team from SJTU and Shanghai First People's Hospital developed Laser venous closure assistant prototype

Contents

6.内視鏡手術 Endoscopic surgery

Endoscopic MIS

01 **Laparoscopic surgery**
Cholecystectomy, Appendectomy、Gastric perforation repair, Liver cyst fenestration, Splenectomy, Drainage of hepatic abscess, Ascites checking, Neoplasm recurrence

02 **Thoracoscopic surgery**
Diagnostic surgery and Curative surgery : pleura, lung, Mediastinum, Pericardial disease, Thoracic trauma, Esophageal disease

03 **Gynaecologic surgery**
Hysteroscopy, Peritoneoscope, Colposcope

04 **Urology surgery**
Bladder cutting, Ureteroscope, Percutaneous nephrolithotomy

Arthroscopic surgery

6.内視鏡手術 Endoscopic surgery

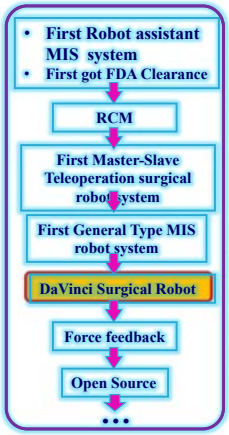
Brief summary based R&D experiences: key technical aspects

Configuration synthesis of slave surgical robot Ergonomic design and system integration	Good surgical manipulators and forceps with enough dexterity and manipulability	Master –Slave mapping Hand-eye coordination Arms coordinated control strategy	Surgical robot system security , reliability Emergency management	Surgical simulation and training system Modular design	Clinical experiment and examination Medical instrument certification

6.内視鏡手術 Endoscopic surgery

Multi-KeyHole Endoscopic Surgical Robots Development History

- In 1994, Computer Motion Company from USA developed AESOP-1000, and released the improved version AESOP-2000, AESOP-3000 later.
- In 1995, IBM Developing Center and John Hopkins University from USA cooperated and developed HISAR and LARS, LARS used the remote center of motion mechanism(RCM)
- In 1995, NASA and MicroDexterity Inc. developed MicroDexterity
- In 1998, Computer Motion Company from USA developed ZEUS
- In 2000, Intuitive Surgical Company from USA developed da Vinci Surgical System and got clearance from FDA in 2001. It merged with Computer Motion in 2003 and combined the technic from ZEUS, then developed the current Da Vinci series
- In 2009, DLR from Germany developed DLR MiroSurge, which realized force feedback in the tele-surgery by installing six-axis force sensor in the forceps
- In 2012, seven universities in USA cooperated to develop the Raven surgical robot system, which realized distributed system based on open source ROS



6.內視鏡手術 Endoscopic surgery

AESOP (Automated Endoscopic System for Optimal Positioning), is the world's first endoscopic minimally invasive surgical robot developed by Computer Motion in 1991. In 1994, AESOP1000 surgical robots got the clearance form US Federal Drug Administration (FDA).

6.內視鏡手術 Endoscopic surgery

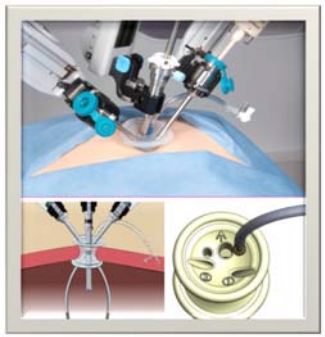
In 1996, Computer Motion Company developed ZEUS and got FDA clearance in 2001. And it was stopped production until the Intuitive Surgical Inc. and Computer Motion Inc. merged in 2003.

6.內視鏡手術 Endoscopic surgery

da Vinci system launched by Intuitive Surgical Inc.in 1998 become the most successful case for multi-keyhole surgical robots: technical development, clinic application, marketing

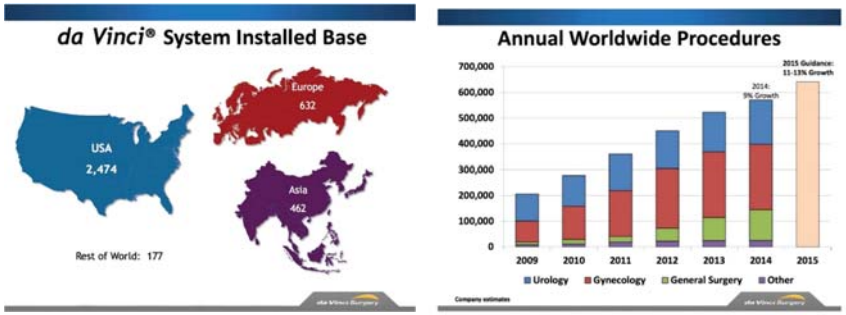
6.內視鏡手術 Endoscopic surgery

da Vinci Multi-KeyHole Surgical Robot System



da Vinci Single Port Surgical Robot System

6.内視鏡手術 Endoscopic surgery



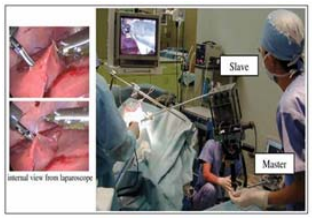
By Feb. 2016, the total number of installations in the world reached 3745, and 58 in China(62 by Jan. 2017)

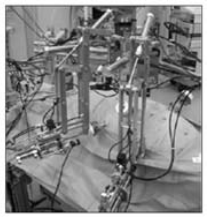
In 2015, the annual number of surgeries assisted by da Vinci reached 620,000

6.内視鏡手術 Endoscopic surgery

In 2005, Washington University, UC Santa Cruz and other units together developed Raven II system, and they have released Raven IV. It is more compact, portable and cheaper than da Vinci system.

6.内視鏡手術 Endoscopic surgery





In 2006, Nagoya University(Japan) developed the Hyper Finger system. Its manipulator is small, which can be used in a small or deep space for surgery like ENT and esophageal surgery.
In 2008, Waseda University(Japan) developed a robotic system that could operate on the beating heart that was placed on a 6-DOF parallel robot platform to simulate the beating of the heart.
In 2010, Tokyo Institute of Technology(Japan) developed a surgical robot system that achieved three-dimensional force detection based on pneumatic servo drive technic.

6.内視鏡手術 Endoscopic surgery

Titan：Amadeus Robotic Surgical System

DLR：MiroSurge

TransEnterix：TELELAP ALF-X

Washington Uni：RAVEN

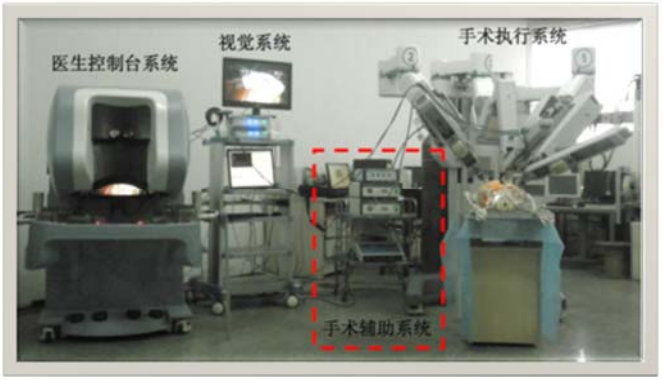
Front Key Technologies for Multi-KeyHole Surgical robots:

Ergonomics Design	Open endoscope	Haptic and tactile feedback	Distributed layout
Instrument repeatability	Overall economy	Eye movement following control	Open framework

6.内視鏡手術 Endoscopic surgery

Tianjin University and Tianjin Medical University together developed microsurgical robotic “MicroHand” system

6.内視鏡手術 Endoscopic surgery



Endoscopic surgical robot developed by HIT Univ.

6.内視鏡手術 Endoscopic surgery

Endoscopic MIS system by BOSHI Ltd.

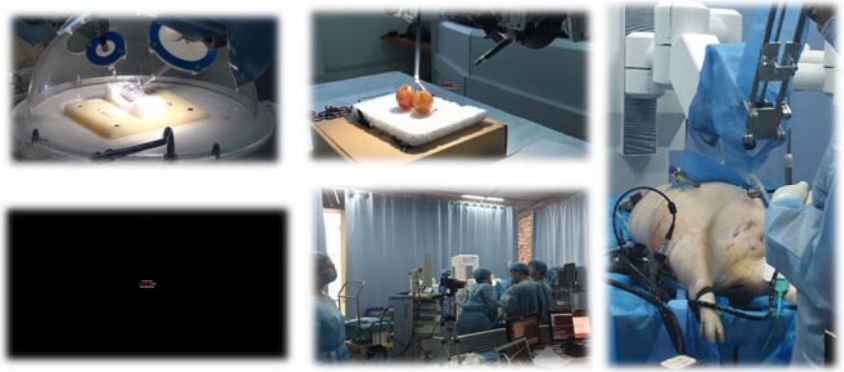
6.内視鏡手術 Endoscopic surgery

Highlights

- 3D display with naked eyes
- Eye tracking and control
- Componentized and collaborative control
- Virtual fixture
- Arm driven without wirerope
- Simulation and distributed control with ROS
- Ergonomic design

Prof.Qixin Cao’s research team from SJTU , Jinshan Group and Prof. Pan from Shanghai Second Military ---- jointly developed “JiaoLong” Surgical Robot System

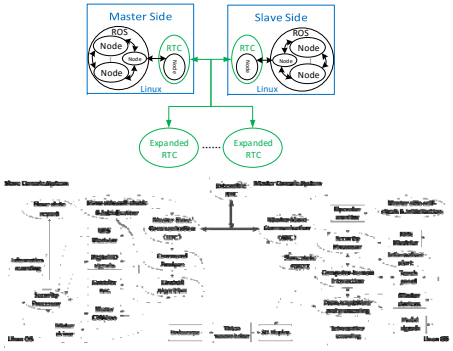
6.内視鏡手術 Endoscopic surgery

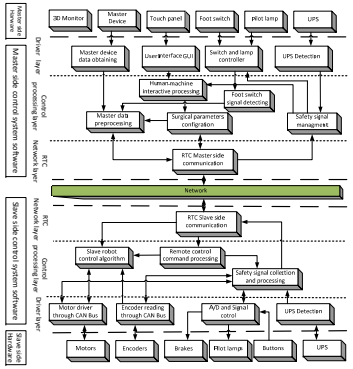


Experiments with the Multi-KeyHole MIS system “JiaoLong” from SJTU Prof. Cao team

6.内視鏡手術 Endoscopic surgery

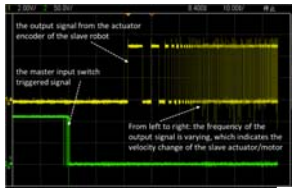
- Proposed the novel ROS + RTC robotic control system architecture

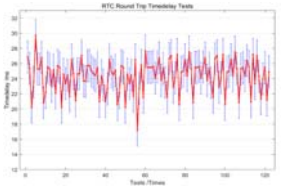


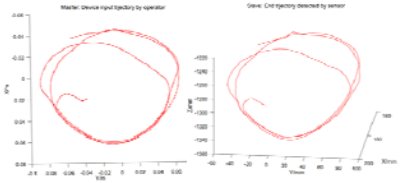


6.内視鏡手術 Endoscopic surgery

- Performance test for the proposed the novel ROS + RTC robotic control system



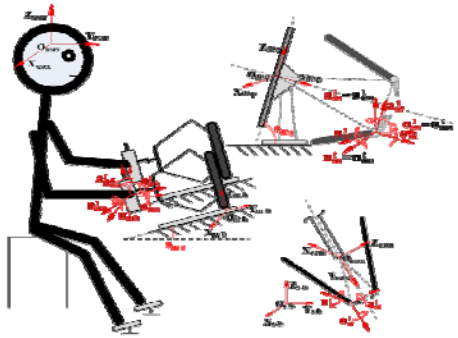




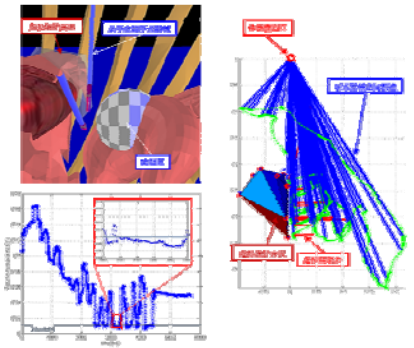
- **Master Slave TeleOperation Single Trip Time Delay Average Value: 23.6ms**
- **RTC Communication Round Trip Time Delay Average Value: 24.4ms, Single Time Delay: 12.2ms**
- **The RTC new control system with proposed novel architecture can achieve good following performance。**

6.内視鏡手術 Endoscopic surgery

- Hand eye coordinate master slave control



- Virtual fixture security mechanism



6.内視鏡手術 Endoscopic surgery

Single Port Endoscopic Surgical Robots

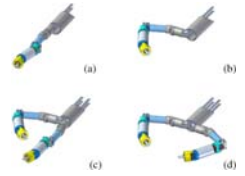
- In 2009,J.R.Romanelli and D.B.Earle from USA developed a surgical device that got three access through single port. It needs manual operation.

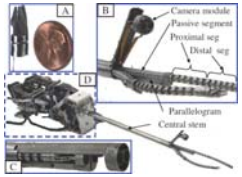
This kind of manual devices belongs no longer to Single Port Robotic System currently.

- In 2009, C.Ishii from the school of engineering at the university of Chicago and K.Kobayashi from Toyota Company developed a kind of manipulator using rotation and DSD mechanism.

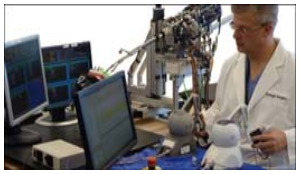
6.内視鏡手術 Endoscopic surgery

Overseas Researches of Endoscopic SPS Robots

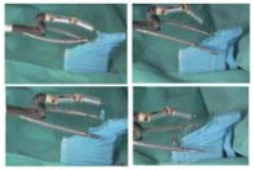




SPRINT CRIM Lab, Scuola Superiore Sant'Anna, Italy



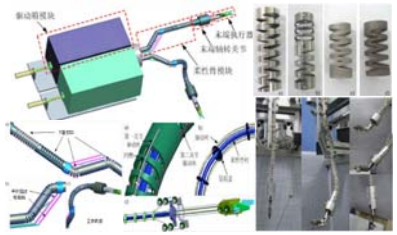
N. Simaan and Xu Kai, Columbia University



Imperial College London, UK

6.内視鏡手術 Endoscopic surgery

Domestic Researches of Endoscopic SPS Robots



HIT, Flexible joints with superelastic Nitinol alloy pipe

Tianjin Univ. and Tianjin Medical Univ. modularized flexible joint design

6.内視鏡手術 Endoscopic surgery

Domestic Researches of Endoscopic SPS Robots

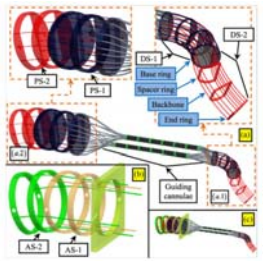


Fig. 3. (a) Dual continuum mechanism, (b) actuation structure, and (c) dual mechanism assembled into the actuation structure: DS, PS, and AS stand for the distal segment, the proximal segment and the actuation segment, respectively.

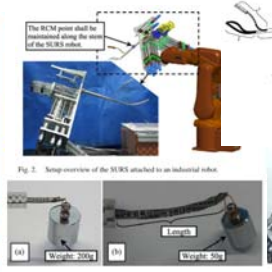
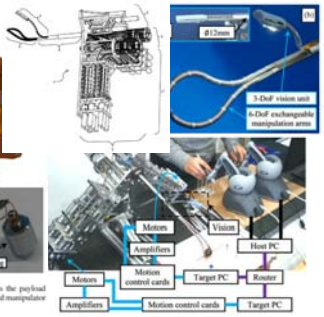


Fig. 4. Torsional stability of a continuum manipulator affects the payload capability: (a) shortened manipulator lifted 200 g, and (b) extended manipulator failed to lift 50 g.



Researchers in SJTU developed SURS based on robot prototype built in Columbia University

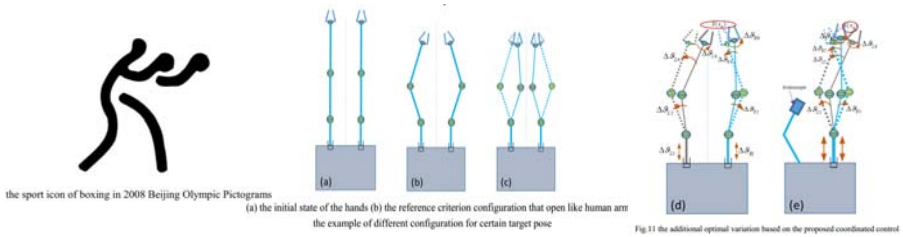
6.内視鏡手術 Endoscopic surgery

Domestic Researches of Endoscopic SPS Robots

Prof.Qixin Cao's research team from SJTU, Prof. Fujie from Waseda University and Renji Hospital developed the "JiaoLong" SPS Robot System

6.内視鏡手術 Endoscopic surgery

A Novel Optimal Coordinated Control Strategy for the Updated Robot System for SPS



the sport icon of boxing in 2008 Beijing Olympic Pictograms

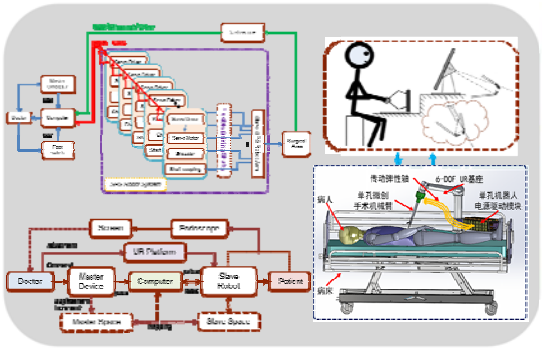
(a) the initial state of the hands (b) the reference criterion configuration that open like human arm the example of different configuration for certain target pose

Fig.11 the additional optimal variation based on the proposed coordinated control

——The International Journal of Medical Robotics and Computer Assisted Surgery

"JiaoLong" SPS Robot System form SJTU and Animal Experiments

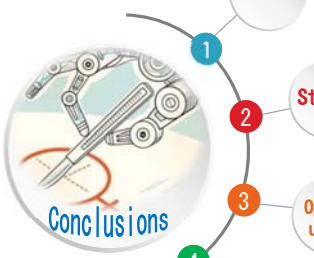
6.内視鏡手術 Endoscopic surgery



"JiaoLong" SPS Robot System form SJTU and Animal Experiments

Contents

7.結論と展望 Conclusion and Outlook



Market

高齢化社会や環境悪化に伴って、癌の発生率、慢性疾患も増加し、医療機器の需要が急増しています。今後15年間に予想される中国は世界最大の市場になるだろう、医療手術用ロボットの強気市場の成長です。

Status

ダ・ヴィンチような手術ロボットは、特許保護、厳格な検査システムの状態とは、市場を振ることができません。中国の手術ロボットの発展は遅れて、全体のサプライチェーいや競争力の不足になっています。.

Opportunity

医療機器のインテリジェント、ネットワーキング、ビッグデータは、.車線変更に追い越し機会を来ています。ダ・ヴィンチ手術ロボットにより、侵襲性の低い、回復速い単孔手術ロボットは、単孔手術ロボットは、次世代手術ロボットの発展方向として認識されます。

Strengths

次世代手術ロボットの研究について、中国と先進国との技術差はあまりないですが、中国での臨床アプリケーションデータの数が多い、この利点が反映されますと信じています。 .

Thank you !

本プレゼンテーションPPT資料の準備、白卫邦、王鹏飞、陈斌斌、李稣からご協力のことを感謝します！