2019 Netval Summer Conference  
September 18, 2019  
CNR, Rome, Italy

Biomedical Technologies for Clinical Innovation

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The cerebral ventricles in Leonardo's anatomical drawings

The refined anatomical knowledge of the brain, combined with further knowledge regarding cranial nerves (auditory and trigeminal) obtained through this procedure, led Leonardo to abandon the functional theory not supported by this newly acquired empirical evidence.

Leonardo’s wax injection method clearly shows that scientific progress is often driven by revolutionary uses of existing tools rather than by groundbreaking ideas.


FAST – Institute of Philosophy of Science and Technology – Università Campus Bio-Medico di Roma
Innovation forecasting is challenging…

1982 (based on P. Dick’s novel published in 1969)  
Martin Cooper, Motorola. 1973
The Future of Medicine

Symptom-based

Intuition medicine
Interaction-based Medicine

Stethoscope

Theophile Hyacinthe Laennec (1816)
The Future of Medicine

1.0 Symptom-based
   \textit{Intuition medicine}

2.0 Interaction-based
   \textit{Measure medicine}
The Future of Medicine

1.0 Symptom-based
   *Intuition medicine*

2.0 Interaction-based
   *Measure medicine*

3.0 Pattern-based
   *Evidence medicine*
Hierarchy of Evidence in Public Health

- Systematic Reviews and Meta-analyses
- Randomized Controlled Double Blind Studies
- Cohort Studies
- Case Control Studies
- Case Series
- Case Reports
- Ideas, Editorials, Opinions
- Animal research
- In vitro (‘test tube’) research

The death valley
Butler, Nature 2008
Evidence Medicine - *Pattern-based*

**Personalized medicine: Time for one-person trials**

Nicholas J. Schork

29 April 2015

Precision medicine requires a different type of clinical trial that focuses on individual, not average, responses to therapy, says Nicholas J. Schork.
The Future of Medicine

Scientific wellness embodies **P4 MEDICINE:**

- **PREDICTIVE**
  - Genetic risks for many diseases are identified. Signs of illness are recognized, before it manifests. The effects of disease are known and planned for in advance.

- **PERSONALIZED**
  - The focus of care is on the individual and how to optimize wellness by predicting disease and personalized treatments to prevent it.

- **PREVENTIVE**
  - Individuals are given the tools to recognize the earliest signs of disease, when it’s most reversible.

- **PARTICIPATORY**
  - Individuals are well informed about their health and better prepared to make their own health care decisions. This makes medicine far more efficient.
The Future of Medicine

1.0
Symptom-based
*Intuition medicine*

2.0
Interaction-based
*Measure medicine*

3.0
Pattern-based
*Evidence medicine*

4.0
Algorithm-based
*4P medicine*
BIOMEDICAL BIG DATA

- Wearable system for the continuous monitoring of physiological parameters
- Environmental conditions monitoring
- Real-time data collection and storage
- Human-computer interfaces (HCI) to assess the patient’s progress and to enhance the patient’s engagement
• Integration of
  • Pathomics, Genomics, Phenomics and Exposome Data
  • Images routinely collected in cancer diagnosis and treatment to
    1. Forecast tumour prognosis
    2. Clinical decision personalization
    3. Treatment selection
    4. Update treatment plans

**Joint Laboratory on Precision Medicine and BioData Analytics**
**Università Campus Bio-Medico di Roma & Centro Diagnostico Italiano**
Evolution of Enabling Technologies for Innovation in Healthcare

Information Technology

data storage, management and analytics

e-Health
Evolution of Enabling Technologies for Innovation in Healthcare

- Information Technology: data storage, management and analytics
- Communication Technology: data exchange, ubiquitous access, patient empowerment

- e-Health
- m-Health
- Patient awareness and empowerment
- ICT-based services
- Self-administered assessment and therapy
- Early discharge of patients at home
- Home/Remote delivery of therapy to reduce treatment-related mobility costs
- Lack of spaces where delivering therapy
BRAIN INNOVATIONS proposes complete solution that addresses all the needs of Parkinson’s Disease patients with the following instruments:

- **Answer to PD - Diagnosis device**
- **Answer to PD - Symptoms monitoring device**
- **PD Assistant - Oral Therapy device**
- **PD Assistant - Infusional therapy device**
The only *all-in-one & plug-and-play* rehabilitation system

- Enabling home rehabilitation scenarios
- Portable, low weight and size
- Better interactive performance with patients
- Performance evaluation

*Heaxel* is a newco of *ICan Robotics & VERTIS SGR, the 1st spin-off accredited by UCBM*  

[www.haexel.com](http://www.haexel.com)
Evolution of Enabling Technologies for Innovation in Healthcare

From electronic-Health and mobile-Health to.......... automated-Health
Managing Health and Care In the Digital Age

Percent of process automation as gauged by workflow

Robotic systems for service applications in hospitals
The health AI market is set to grow significantly, with acquisitions of AI startups increasing rapidly. The market is expected to reach $6.6B by 2021, representing a CAGR of 40% through 2021.

**Health AI Market Size 2014-2021**

- **2014**: $600M
- **2021**: $6.6B

**AI can address unmet clinical demand**

- **Clinic Demand**: 20% estimated unmet demand addressable via AI

**Application Value**

- Robot-Assisted Surgery: $40B
- Virtual Nursing Assistants: $20B
- Administrative Workflow Assistance: $18B
- Fraud Detection: $17B
- Dosage Error Reduction: $16B
- Connected Machines: $14B
- Clinical Trial Participant Identifier: $13B
- Preliminary Diagnoses: $5B
- Automated Image Diagnoses: $3B
- Cybersecurity: $2B

**TOTAL = $150B**
Robot-assisted Surgery
Robot-assisted Surgery

Figure 8.
Lenny, Mona, and da Vinci patient-side manipulators.

Figure 9.
Lenny, Mona, and da Vinci master controllers.

Origins of Robotic Surgery: From Skepticism to Standard of Care

Journal of the Society of Laparoendoscopic Surgeons

JSLS. 2018 Oct-Dec; 22(4): e2018.00039
DOI: 10.4199/JSLS.2018.00039
PMID: 30521654

Robotic Surgery: From Skepticism to Standard of Care

Edward L. Dineen, MD, COL Timothy D. Shanks, MD, COL Richard A. LaPorta, MD, Jerome Manzuso, MD, and COL Richard M. Saylor, MD.

UNIVERSITA' CAMPUS BIO-MEDICO DI ROMA
www.unicampus.it
Robot-assisted Surgery

An example setup of the *da Vinci Si* system. (Image credit: Intuitive Surgical Inc.)
NOTES: flexible endoscopic multitasking platforms

Direct Drive Endoscopic System

Endosamurai

ANUBIS

COBRA (USGI)

Endovia

SPIDER surgical system
CADAVER TEST: May 24th-25th, 2018

I. Portaccio, G. Vadala, D. Accoto et al., UCBM, BIOROB 2016
Robot-aided Transcranial Magnetic Stimulation

- High accuracy in coil positioning
- High repeatability stimulating the same site
- Automatic hot-spot identification
- Head motion compensation

- High stiffness in stimulation plane → high accuracy
- Compliant behavior perpendicular to the head → safety and comfort for the subject
BIO-COOPERATIVE ROBOTIC SYSTEMS FOR REHABILITATION

Final prototype tested on a patient affected by SLA

Robotic arm controlled by subjects with Spinal cord injury


CONVEGNO SCIENTIFICO MANO BIONICA
DALLE ORIGINI DELLA RICERCA ALLE Sperimentazioni su Soggetti Amputati

Giovedì 21 febbraio 2019 ore 08:00
Accademia Nazionale dei Lincei
Palazzo Corsini
via della Lungara 10
Roma
To recover sensorimotor integration through neural electrodes and to enable real-time closed-loop control of bionic hands in tasks of fine grasp and manipulation, by using routed sensory information.

Increasing complexity and improvement over time

- Lateral grasp
- Pick and place with Power grasp
- Pick and place with Precision grasp
- Manipulation task

- Improvement of grasping and manipulation capabilities over time
- Interoperability: one research prototype and one commercial hand.


Manipulation task with neural feedback (commercial prosthesis)
Market Trends

• The **Medical Robots** market is projected to reach USD 12.80 billion by 2021 from USD 4.90 billion in 2016, growing at a CAGR of 21.1% during the forecast period.

• In 2016, the **Surgical Robots** segment commanded the largest share of medical robot systems. However, the **Rehabilitation Robot** systems are likely to grow at the highest CAGR during the forecast period.

• The global **Medical Robotics & Bionics** market was valued at USD 15,348 million in 2016, and is expected to garner USD 29,160 million by 2023, registering a CAGR of 9.6% during the forecast period.

[https://www.alliedmarketresearch.com/medical-bionics-market](https://www.alliedmarketresearch.com/medical-bionics-market)

Robotic for Medical Applications

- Diagnosis
- Assisted Surgery and Acute Treatments
- Assisted Recovery, Post-acute Treatments
- Independent Living, Multi-cronicity
IEEE TRANSACTIONS ON
MEDICAL ROBOTICS
AND BIONICS

A PUBLICATION OF THE IEEE ROBOTICS AND AUTOMATION SOCIETY
THE IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY

FEBRUARY 2019 VOLUME 1 NUMBER 1 ITMRBT (ISSN 2576-3202)

INAUGURAL ISSUE LINKED TO THE 7TH IEEE INTERNATIONAL CONFERENCE ON BIOMEDICAL ROBOTICS AND ROBOMEDICINE (BIOROBOT)

EDITORIAL

Medical Robotics and Bionics: A New Interdisciplinary Adventure
P. Dario

GUEST EDITORIAL

A Perspective of BioRobotics From the IEEE RAS/EMBS BioRob 2018 Conference
S. Misra and H. van der Kooij

PAPERS

Reconstructing Tissue Properties From Medical Images With Application in Cancer Screening
S. Yang, J. Liang, V. Jojic, J. Lian, R. C. Chen, and M. C. Lin

On the Use of a Continuum Manipulator and a Bendable Medical Screw for Minimally Invasive Interventions in Orthopedic Surgery
F. Alambeigi, M. Bakhtiarinejad, S. Sefati, R. Hegeman, I. Iordachita, H. Khanuja, and M. Armand

Funicular Flexible Crawler for Colonoscopy
J. Nagase, F. Fukunaga, K. Ogawa, and N. Saga

Preliminary Validation of a Cable-Driven Powered Ankle–Foot Orthosis With Dual Actuation Mode
Y. Zhang, R. J. Kleinmann, K. J. Nolan, and D. Zanotto

A Knee–Ankle–Foot Orthosis to Assist the Sound Limb of Transfemoral Amputees
C. B. Sanz-Moré, M. Fantozzi, A. Parri, F. Giovacchini, A. Baldoni, M. Cempini, S. Crea, D. Lefeber, and N. Vitiello

Concerted Control of Stance and Balance Locomotor Subfunctions—Leg Force as a Conductor
A. Sarmadi, C. Schumacher, A. Seyfarth, and M. A. Sharbafi

Estimation of Phantom Arm Mechanics About Four Degrees of Freedom After Targeted Muscle Reinnervation
M. Sartori, J. van de Riet, and D. Farina

IEEE
The European Medical Technology Industry - in figures / 2018, MedTech Europe, [www.medtecheurope.org](http://www.medtecheurope.org)
Thank you!

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