HUMANOID RESEARCH FOR BRAIN IMPAIRMENT

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The Human Brain Project

- The winner of the European Commission competition of Future and Emerging Technologies (FET) in 2013.
- 1.19 billion € over 10 years.
- The principal investigators include 33 scientists from Germany.
- The "Human Brain Project" will develop the most detailed model of the brain, for studying how the human brain works and ultimately to develop personalised treatment of neurological and related diseases.
Today at the White House, President Obama unveiled the “BRAIN” Initiative - a bold new research effort to revolutionize our understanding of the human mind and uncover new ways to treat, prevent, and cure brain disorders like Alzheimer’s, schizophrenia, autism, epilepsy, and traumatic brain injury.

“...”

~ CNN 2 April 2013 ~
Funded by the Ministry of Education Malaysia

The objective of the grant is to uplift and develop niche areas
Background

- **Autism Spectrum Disorder**: 1 in 150 live births
- **Cerebral Palsy**: 2 in 1000 live births
- **Stroke**: 5-7% aged more than 65 years old
- **Post Traumatic Stress Disorder**: 3.6 in 100 (18 - 54 years old)
- **Alzheimer’s**: 4.5% aged 75 years old
- **Parkinson’s**: 20-280 / 100,000
Background

- Seriousness of brain impairment globally and locally
  - A grand challenge even by the US
- Existing therapies (include medication, dietary, surgery etc.) are limited
  - Requires alternative approaches
- Humanoid-based Intervention is proposed
  - Human-based Studies & Technological Approach
- Outcomes
  - Theory and technology on humanoid design for brain impairment
Brain Impairment

Childhood

- Autism
- Down Syndrome
- Cerebral Palsy

Adult

- Alzheimer’s
- Parkinson
- Trauma
- Stroke

Conventional Treatment:
- Behavior & Communication Approaches (Education)
- Dietary Approach
- Medication
- Complementary & Alternative Medicine

Involves multidisciplinary professionals:
- Neurologists
- Rehabilitation Physicians
- Psychiatrists & Psychologists
- Occupational Therapists
- Physiotherapists
- Speech & Language Therapists
- Special Education Teachers
- Dieticians
The main gaps/shortcomings:

- Neurological Diseases lack of specific drugs
- Lack of systematic intervention in brain impairment
- Multiple professionals for personal care
- Lack of advanced technological tools

Proposal:
Therapy Augmentation via Humanoid Therapy / Rehabilitation
Objectives

- To characterize the key interactions between humanoid and subject
- To formulate the technological environment for the humanoid therapy/rehabilitation
- To define the social and ethical impact on the humanoid therapy/rehabilitation
How Humanoid Therapy / Rehabilitation can Help?

Physically more approachable

Teach how to detect and understand emotions and social behaviours

Provoke interactive and social responses

To overcome the impairments in terms of:

• Social Interaction
• Communication Skills
• Imaginative Play associated with Repetitive Behavior
Subprojects (SP)

TECHNOLOGY-BASED STUDIES

SP1: Humanoid System with Embedded Devices

SP2: Wireless Network Module inclusive of Security and Advanced Material

SP3: Advanced Sensor Modules

HUMAN-BASED STUDIES

SP4: Kinesiology Studies

SP5: Brain Impairment Studies

SP6: Social Implications of Technology
SP1: Humanoid System with Embedded Devices

- **Motivation**
  - Humanoid-based augmented brain impairment therapy

- **Objective**
  - To characterize a humanoid for augmented brain impairment therapy

- **Methodology**
  - Humanoid algorithm
SP2: Wireless Network Module, Security & Advanced Material

- **Motivation**
  - Light-weight information sharing architecture

- **Objective**
  - Wireless, secured, compact & high performance network modules

- **Methodology**
  - Establish 3D on-substrate circuit architecture with light-weight cryptographic-based communication, based on advanced material
SP3: Advanced Sensor Modules

Human-Humanoid Complex Physical Interactions

- Motivation
  - Combination of memristor ability to act as memory and fundamental circuit element, and the material sensing ability

- Objective
  - To synthesize and characterize memristor-based sensors

- Methodology
  - New material synthesis
  - Device structure
  - Circuit topology
Subject Movement Examination

- Temporal-spatial parameters
- Gait symmetry
- Joint angles & moments
- Motion capture

**Motivation**
- Brain impairment disease relates to deformation in physical movement

**Objective**
- To characterize physical movement of brain impairment subject

**Methodology**
- Neuro-muscular, gait analysis and feature extraction
**SP5: Brain Impairment Studies**

**Subject Behaviour Examination**

- Humanoid Robot Interaction
- Assessment Method
- Measuring outcomes
- Cognitive recovery

**Motivation**
- Augmentative treatment in brain impairment diseases

**Objective**
- To formulate assessment method in evaluating the performance of humanoid intervention

**Methodology**
- Clinical studies
- fMRI verification
SP6: Social Implications of Technology

Conceptual Framework

- Social & behavioral aspect
- Policy & guideline aspect
- Economical (cost benefit) aspect
- Future trends towards treatment & intervention

**Motivation**
- Any alternative technology-based approach will require studies on social implications

**Objective**
- To formulate conceptual framework of humanoid-based brain impairment augmented therapy

**Methodology**
- Qualitative research approach
Pilot Experiment of Robot-based Intervention for Autism
The Gait Study
Long-Term Outcomes

• Better understand the humanoid-based rehabilitation mechanisms for brain impairment diseases

• Reduce language barriers through technological advances in how technology interact with human

• Develop solutions to prevent, treat, or even reverse the harmful effects of PTSD and Traumatic Brain Injury

• Create high-tech jobs in cutting-edge industries of the future
Future Humanoid: Brain Impairment Friendly

- Ergonomics
  - Industrial design
- Complete cyber physical system
- Light-weight material
- Wireless power transfer
- Improved movement resolution
- Spiritually motivated (Islam)
Trans-disciplinary Involvements

- Microwave Technology Centre
- Humainoid Robot & Bio-Sensing Centre
- Faculty of Mech. Eng.
- Faculty of Elect. Eng.
- Faculty of Maths & Computer Sc
- Fac. of Admin. Sc. & Policy Studies
- Faculty of Business & Mgt
- Institute of Business Excellence
- Institute of Science
- RMI Kinesiology Laboratory
- Faculty of Pharmacy
- Faculty of Health Science
- Faculty of Medicine
- Faculty of Applied Science
- Faculty of Art & Design
- Faculty of Arch, Survey & Planning
Fundamental researches in various disciplines

HUMANOID: Integration of indigenous technologies (wireless modules, advanced tactile sensors)

INFORMATION ARCHITECTURE: Behavioral, Therapy, Movement, Human-robot interaction

CLOUD COMPUTING

HUMANOID: Wireless power transfer, Intelligent sensors, Ubiquitous connectivity

INFORMATION ARCHITECTURE: Alzheimer's, Down Syndrome, Parkinson, PTSD, Traumatic Brain Injury

CLOUD COMPUTING

2013 Humanoid Research for Brain Impairment

2017 Advanced Humanoid for Autism

2020 Intelligent Humanoid for Brain Impairment
Roadmap for Human-Based Studies

Fundamental researches in various disciplines focusing on Humanoid-Augmented Therapy for Autism

- 2013 Human-Robot Interaction for Children
- Socio-economic impacts of technology

2017 Human-Robot Interaction for Adult
- Spiritual studies (Islam)

2020 Human-Robot Interaction for PTSD
- Spiritual intervention (Islam)

Humanoid-Augmented Therapy for Alzheimer’s

Humanoid-Augmented Therapy for PTSD

INFORMATION ARCHITECTURE
Big Data & Analytics

e-services

Spiritual studies (Islam)
Ethics Approval

- Medical Research and Ethics Committee, Ministry of Health Malaysia
- Research Ethics Committee, Universiti Teknologi MARA
Concluding Remarks

- A truly interdisciplinary research initiatives with future commercial potential
- Multi-faculty, multi-centre involvements
- High proportion of aspiring junior lecturers for long-term sustainability with international potentials
Invitation for Collaboration

www.robinuitm.com
http://uitmniche.myapmttemc.org

“Collaborate, collaborate, collaborate. This is our opportunity.”

Prof. Karlheinz Meier, University of Heidelberg, Co-director of the HBP and co-leader of the Neuromorphic Computing Subproject
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Thank you for your attention!