



# 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.

o 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.

### Niche Research Grant Scheme



## 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
- o Post Traumatic Stress Disorder: 3.6 in 100 (18 54 years old)
- o Alzheimer's: 4.5% aged 75 years old
- o 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

Congenital

Adult

Acquired

Autism
Down Syndrome
Cerebral Palsy



Alzheimer's Parkinson Trauma Stroke

#### **Conventional Treatment:**

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

#### Involve multidisciplinary professionals:

- Neurologists
- Rehabilitation Physicians
- Psychiatrists & Psychologists
- Occupational Therapists
- Physiotherapists
- Speech & Language Therapists
- Special Education Teachers
- Dieticians

### **Problem Statement**

#### 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

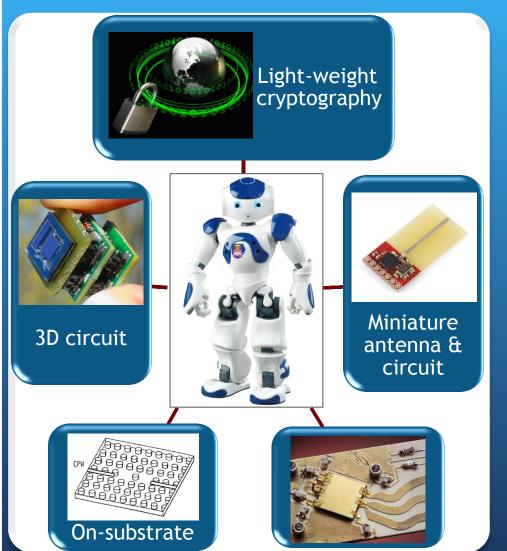
#### Objective

 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

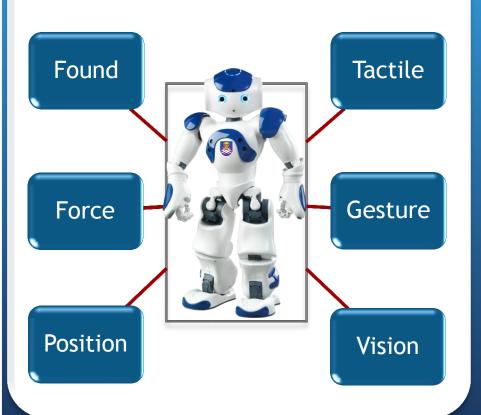
Wireless, secured, compact
 & high performance
 network modules

#### Methodology

 Establish 3D on-substrate circuit architecture with light-weight cryptographicbased 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

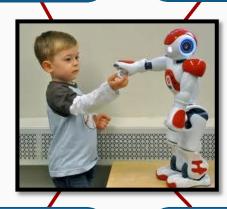
- New material synthesis
- Device structure
- Circuit topology

## **SP4: Kinesiology Studies**

#### Subject Movement Examination

Temporalspatial 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 Assessment Robot Method Interaction Cognitive Measuring recovery outcomes

#### Motivation

Augmentative treatment in brain impairment diseases

#### Objective

 To formulate assessment method in evaluating the performance of humanoid intervention

#### Methodology

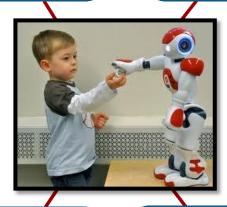
- Clinical studies
- fMRI verification

# 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 technologybased approach will require studies on social implications

#### Objective

 To formulate conceptual framework of humanoidbased 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

Spiritually motivated (Islam)

Complete cyber physical system

Improved movement resolution

Light-weight material

Wireless power transfer

## 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

## Roadmap for Technology-Based Studies

CLOUD COMPUTING

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

**HUMANOID:** 

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

Fundamental researches in various disciplines

2013
Humanoid
Research for
Brain
Impairment

CLOUD COMPUTING

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

HUMANOID:

Wireless power transfer, Intelligent sensors, Ubiquitous connectivity

**2017**Advanced
Humanoid
for Autism

2020 Intelligent Humanoid for Brain Impairment

### Roadmap for Human-Based Studies

e-services

INFORMATION
ARCHITECTURE
Big Data &
Analytics

Fundamental researches in various disciplines focusing on Humanoid-Augmented Therapy for Autism Humanoid-Augmented Therapy for Alzheimer's Humanoid-Augmented Therapy for PTSD

2017

Human-Robot Interaction for Adult

Spiritual studies (Islam)

2020

Human-Robot Interaction for PTSD

Spiritual intervention (Islam)

2013

Human-Robot Interaction for Children

Socio-economic impacts of technology

## **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

<u>www.robinuitm.com</u>
htttp://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!