NCTU’s Research in Response to Grand Challenges

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President
National Chiao Tung University
08/15/2018
History

- Founded in Shanghai, China in 1896 and re-established in Hsinchu, Taiwan in 1958 as an engineering research university

Today

- A comprehensive university consisting of 11 colleges with 720+ full-time faculty members and roughly 13,000 students, 57% being post-graduates
- An internationalized campus attracts 1600+ international students from 60+ countries

Location (7 km science-based smart corridor)

- Main campus at Hsinchu Science Park and surrounded by 7 national research centers and labs
  - National Synchrotron Radiation Research Center (NSRRC)
  - National Measurement Laboratory (NML)
  - National Center for High-performance Computing (NCHC)
  - National Space Organization (NSPO)
  - National Chip Implementation Center (CIC)
  - National Nano Device Laboratories (NDL)
  - Instrument Technology Research Center (ITRC)
Pillar for TAIWAN’s Semiconductor Research

Semiconductor Industry in Taiwan
- 25% of worldwide revenue in 2017
- 12% of Taiwan’s GDP and 20% of its export value*
- Global leader in advanced manufacturing

NCTU is Cradle of Taiwan’s Semiconductor Industry
- Realized Taiwan’s first transistor
- Realized Taiwan’s first integrated circuit
- Fostered first team for Taiwan’s IC pilot production
- Established first and only International College of Semiconductor Technology

*Source: Market Intelligence & Consulting, Institute for Information Industry, Taiwan
Legacy and Leadership

NCTU-educated Academic Pioneers
- NAE Members: Prof. Chun-Yen Chang, Prof. M.C. Frank Chang
  - The only 2 Taiwan educated PhDs

NCTU-educated High-tech Leaders
- Around 2/3 of founders and CEOs in Hsinchu Science Park are NCTU alumni
- Around 4,000 alumni in TSMC and 2,000 in MediaTek
- Companies founded/managed by NCTU alumni with more than 500 thousand employees and annual revenue of US$200 Billions in 2016

Stan Shih
Acer

Patrick Yang
Merck/Roche

C. C. Wei
TSMC

Evans Tu
Synnex

Archie Hwang
Hermes-Epitek

Jonney Shih
ASUS

Robert Tsao
UMC
Industrial Impacts

NCTU Industry-academia Funding

Average Industry Income Index Score in 5 years

<table>
<thead>
<tr>
<th>Institutions</th>
<th>Industry Income Index Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCTU</td>
<td>95.3</td>
</tr>
<tr>
<td>CMU</td>
<td>53.5</td>
</tr>
<tr>
<td>TIT</td>
<td>67.5</td>
</tr>
<tr>
<td>NTU</td>
<td>49.6</td>
</tr>
<tr>
<td>NTHU</td>
<td>48.1</td>
</tr>
<tr>
<td>NCKU</td>
<td>99.9</td>
</tr>
</tbody>
</table>

Source: Times Higher Education (THE) World University Rankings

Clarivate Analytics : 2017 State of Innovation Report

<table>
<thead>
<tr>
<th>Selected Items</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 10 smart media innovators-Asia</td>
<td>Hon Hai Precision</td>
</tr>
<tr>
<td>Top 10 global innovators-semiconductors</td>
<td>TSMC</td>
</tr>
<tr>
<td>Top 10 semiconductor materials &amp; processes innovators-Asia</td>
<td>TSMC</td>
</tr>
<tr>
<td>Most prolific scientific research institutions in semiconductors</td>
<td>NCTU</td>
</tr>
<tr>
<td>Most prolific scientific research institutions in home appliances</td>
<td>NCKU</td>
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</table>

Note: Clarivate Analytics is formerly the Intellectual Property and Science business of Thomson Reuters
## Research Centers for Grand Challenges

<table>
<thead>
<tr>
<th>Grand Challenges</th>
<th>Advanced Research Centers at NCTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Advance personalized learning</td>
<td>Center for Teaching and Learning Development (CTLD)</td>
</tr>
<tr>
<td>2. Make solar energy economical</td>
<td>Center for Emergent Functional Matter Science</td>
</tr>
<tr>
<td>3. Enhance virtual reality</td>
<td>NCTU IoT Intelligent Systems Technology Center</td>
</tr>
<tr>
<td>4. Reverse-engineer the brain</td>
<td>Brain Research Center</td>
</tr>
<tr>
<td>5. Engineer better medicines</td>
<td>Center For Intelligent Drug Systems and Smart Bio-devices (IDS2B)</td>
</tr>
<tr>
<td></td>
<td>Center for Neuro-Modulation Medical Electronics System</td>
</tr>
<tr>
<td>6. Advance health informatics</td>
<td>Center for Bioinformatics Research</td>
</tr>
<tr>
<td>7. Secure cyberspace</td>
<td>National Cybersecurity Center of Excellence at NCTU</td>
</tr>
<tr>
<td>8. Provide access to clean water</td>
<td>Disaster Prevention and Water Environment Research Center (DPWE)</td>
</tr>
<tr>
<td>9. Manage the nitrogen cycle</td>
<td>Disaster Prevention and Water Environment Research Center (DPWE)</td>
</tr>
</tbody>
</table>
Personalizing the Learning Experience

• Provide resources to learners based on their unique needs
  – Video, Podcast, VR/AR [established OEO, HERO to produce the contents]
• Allow learners to adjust the learning pace
  – QC3, Learning Management System
• Allow learners to design their own learning pathway
  – Open Curriculum, Cross-disciplinary Program [established CTLD to create the regulations and policies]
NPM Open Data System: more than 300 treasures
- AI, AR/VR [toward establishing a virtual museum]
Industrial Connections:

- **Green Energy**: roll-to-roll manufacture and epoxy-based packaging materials (ITRI); wearable solar cell devices (TTRI 紡織研究 所); high-performance solar cell materials (Raynergy).
- **Bio-medical sensing**: nano-biosensing platform & non-invasive biosensor (Exact Biochip & Phison Electronics).
- **X-tronics**: integrating 2D materials for 3-nm-node technology (TSMC); graphene technology (Puritic, ITRI).

Domestic Collaborations:
- RCAS, Academia Sinica
- National Synchrotron Radiation Research Center

International Collaborations:
- RIKEN-NCTU Joint Center (Japan)
- Network Joint Research Center for Materials and Devices (5 Univ. in Japan)
Tin-based perovskite solar cell has attained the world record efficiency 9.6% from NCTU.

(1) Combine several cells in series to charge supercapacitor under room light condition.
(2) Provide electricity for low-power devices such as sensors and RFID tags for IoT applications.
(3) Combined devices can be re-used without issues of recycling like batteries.

Energy & Environmental Science 2018, Accepted (DOI: 10.1039/C8EE00956B).
Advanced Materials 2018, under review.
Virtual Reality (VR) Achieved at NCTU

Collaborating with nVIDIA and Coretronic

Features:
- **Smallest VR module in the world** (Thickness 1cm, Weight 14g)
- Without visual fatigue
- Automatic vision correction (eye-glasses free)

Honor:
- Distinguished Paper of 2018 SID Symposium (only 2%/yr)

Demo with nVIDIA and Coretronic in SID innovation-Zone
Augmented Reality (AR) Achieved at NCTU

Collaborating with Google Day Dream Team

Features:
- Display directly on eye-glasses
- Super wide Field of View (FoV)
- High efficiency/Thin & Light

Honor:
- Google Faculty Research Awards on 2017 (Yi-Pai Huang/Hao-Chung Kuo) & 2018 (Yi-Hsin Lin)
Toward Realistic and Real-World Friendly VR

Pen + VR Classroom

- Integrating natural pen-based interaction for VR classroom.

Haptic Interaction for VR

- Designing graspable shape interfaces for VR
- Producing normal force on user face with HMDs

Read-World Friendly for VR

- Facilitating shared use of the physical space by both VR and external users
**World-Class Stereo Depth Estimation**

- Pyramid Stereo Matching Network (**PSMNet**)
  - Estimate depth using a stereo image pair

- Published in **CVPR 2018**
- **Ranked 1st worldwide** on KITTI leaderboard for 8 months (2017/10/27~2018/06/21)

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<table>
<thead>
<tr>
<th>Method</th>
<th>Setting</th>
<th>Code</th>
<th>D1-bg</th>
<th>D1-fg</th>
<th>D1-all</th>
<th>Density</th>
<th>Runtime</th>
<th>Environment</th>
<th>Compare</th>
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<td>0.25 s</td>
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Reverse Engineered Fly Brain

- 26k neurons were traced (for *skeletonization*), and warped into a typical brain.
- Cluster neurons into *morphological groups* according to shape similarity.
- Reconstruct the *fly brain connectivity* based on the groups (similarity and overlapping).

**View 1**

- Red: visual
- Green: olfactory

**View 2**

- Red: visual
- Green: olfactory
Specific Aims: To provide synergistic solutions to unmet health problems in Taiwan

- Liver and breast cancers,
- Kidney diseases,
- Neural degenerative and retinal diseases

Strategic Development Objective: To achieve these goals, a cross-disciplinary international team, with world-renowned experts in Biology, Bio-Informatics, Materials Science, Chemistry and Physics, together with Clinic Physicians, across the universities including NCTU, NYMU, TVGH, KMU, UCSD, Johns Hopkins U., UCLA, Harvard U. and U. Ottawa are organized to develop

- Precision earlier diagnostics/personalized medicine,
- Intelligent drugs and associated multi-functional drug delivery nanosystems,
- Smart implantable platform with 3D bioprinted functionalized organoids,

Expected milestones:

- Establishing an entrepreneurship outlet with start-up bio-ventures
- Cultivation of world-class talents in Taiwan
The center focuses on researches and developments of implantable medical electronics systems with SoC technology and biocompatible materials, especially for close-loop neuromodulation to treat neuro disorders by electrical voltage/current. The developed neuromodulation systems will be validated in animal tests. Finally, the clinical trials will be performed.
miRTarBase, a microRNA-target interaction database, has been widely used in the world

- >1300 citations
- Cited by miRBase, GeneCards, Ensembl, and Mouse Genome Database ...
- http://miRTarBase.mbc.nctu.edu.tw/

From Health Informatics To Translational Medicine

- MicroRNA biomarkers for early detection and diagnosis of diseases.
- MicroRNA drug targets and therapeutics
Integrating expert experiences and artificial intelligence.

Focusing on:

- Intelligent Malware Analysis & Detection
- Automatic Penetration Test
- Network Attack Detection and Prediction
- Automatic Exploit Generation
- IoT and Mobile Security

Intelligent Malware Detection

Applying Deep Learning for Malware Detection

Intelligent Attack Detection/Prediction

Botnet/Network Attack Detection and Prediction

More Secured Cyberspace
Provide access to clean water

Mission

• Quality production water
• Optimum water treatment performance

Water desalination

• RO system diagnosis and technique development: Nanosilver modified membrane for anti-biofouling
• Development of composite electrodes in capacitive deionization (CDI): Activated carbon/Carbon black and MnO₂ composite electrode

Wastewater reclamation

• Photoelectron semiconductor membrane filtration (PSMF) system for organic removal
• Biochar produced from agricultural waste for the treatment of N/P-containing wastewater
Manage the Nitrogen Cycle

● **N-cycle in the Air**
  ✓ Reduce energy consumption
  ✓ Remove air pollutant and greenhouse gas
  \[\text{NO}_x \rightarrow \text{N}_2\]

● **N-cycle in the wastewater**
  ✓ Produce biogas energy
  ✓ Remove water pollutant
  \[\text{NH}_4^+ \rightarrow \text{N}_2\]
If you want to go fast, go alone. If you want to go far, go together. (African Proverb)

ACT together, we go far!