AI and the 4th Industrial Revolution

SNU AI Course
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http://bi.snu.ac.kr/
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   - Google, Facebook, Amazon, IBM, MS, Apple
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1. AI Technology Trends
Artificial Intelligence AI)

- Machines (SW, robots) that think and act like humans
- Make machines do things at which humans are better
- Solve tasks that, if done by humans, require intelligence
- 1950: Turing’s paper, 1956: “Artificial Intelligence (AI)”
A Brief History of Artificial Intelligence

1970-1980’s: AI Boom
   Expert Systems

1982-1992:
   Fifth-Generation Computer Systems

1990’s: AI Winter
   Neural, Genetic, Fuzzy Systems
   Late 1990’s:
      Internet, Web, Data Mining
      Information Retrieval
      Yahoo, Google

2000’s: Resurgence
   • Intelligent Agents
   • Machine Learning
   IBM “Deep Blue” Chess Machine
   Beats Human Champion (1997)
Success Stories of AI

AlphaGo (Google DeepMind)
Core AI Technology: Machine Learning

- Machines that **learn from experience (data)** like humans
- **Self-improving systems** from accumulated data
- Automated generation of models (programs, pattern/rules, knowledge) from data
- **Automatic programming**, pattern recognition, knowledge discovery/acquisition
Multilayer Perceptron (MLP)
Principles of Learning in Artificial Neural Networks

Error Backpropagation

\[ w_i \leftarrow w_i + \Delta w_i, \quad \Delta w_i = -\eta \frac{\partial E}{\partial w_i} \]

### Information Propagation

Input \( x_1 \)  
Input \( x_2 \)  
Input \( x_3 \)

Input layer  
Hidden layer  
Output layer

Output \( o = f(x) \)

### Error

\[ E_d(\mathbf{w}) = \frac{1}{2} \sum_{k \in \text{outputs}} (t_k - o_k)^2 \]
Why Deep Learning?

- Multiple boundaries are needed (e.g. XOR problem) → Multiple Units
- More complex regions are needed (e.g. Polygons) → Multiple Layers
Deep Learning

[LeCun, 1998]
• Convolutional neural networks based face recognition system is dominant

• 99.15% face verification accuracy on LFW dataset in DeepID2 (2014)
  - Beyond human-level recognition

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Taigman et al. DeepFace: Closing the Gap to Human-Level Performance in Face Verification, CVPR’14
Deep Learning – Object Recognition

- Deep Convolutional Neural Network (CNN)
  - 이미지에서 특징(feature)을 자동으로 추출함
  - 높은 측으로 갈수록 더 복잡하고 종합적인 인식
- ImageNet
  - CNN으로 이미지에서 다양한 종류의 물체를 인식함
  - 약 6천만 개의 매개변수(parameter), 65만 여 개의 인공 신경 세포를 이용해 1천 종류 이미지 약 120만장을 분류
- Human-Level Object Recognition
Deep Learning – Speech Recognition

- ~2010 GMM-HMM (Dynamic Bayesian Models)
- ~2013 DNN-HMM (Deep Neural Networks)
- ~Current LSTM-RNN (Recurrent Neural Networks)
Deep Learning – Video Analysis

- Use 3D CNNs to model the temporal patterns as well as the spatial patterns

S. Ji, K. Yu, et al., PAMI, 2013
Deep Learning – Learning Cartoon Videos

Image 개수: 8500
Word 개수: 800
Episode 개수: 183

[Ha et al., AAAI-2015]
Deep Learning – Movie Recommendation

Smart Models

- Regression models (Logistic, Linear, Elastic nets)
- GBDT/RF
- SVD & other MF models
- Factorization Machines
- Restricted Boltzmann Machines
- Markov Chains & other graphical models
- Clustering (from k-means to HDP)
- Deep ANN
- LDA
- Association Rules
- …
2. AI Industry Trends
Industry Trends in AI

- 2005: DARPA Grand Challenge (Thrun)
- 2006: Deep Neural Networks (Hinton, Science)
- 2008: Neural Networks and Learning Machines (Haykin)
- 2009: Apple Siri personal assistant
- 2009: Google self-driving car
- 2011: IBM Watson AI supercomputer
- 2012: Google acquires DNNresearch (Hinton)
- 2012: Deep learning breakthroughs (Google, MS)
- 2013: Human Brain Project HBP (EU)
- 2013: Quantum AI Lab for machine learning (Google, NASA)
- 2013: Amazon Prime Air (Drones)
- 2013: Google acquires Boston Dynamics (Robotics)
- 2013: Facebook AI Lab in New York (LeCun)
- 2013: Allen Institute for Artificial Intelligence (AI2)
- 2014: Google acquires DeepMind for $400M
- 2014: Baidu Institute of Deep Learning in Silicon Valley (Ng)
- 2014: Jibo robot raises $25M by crowdfunding (MIT Breazeal)
- 2015: IARPA Machine Intelligence from Cortical Networks
- 2015: Musk donates $10M for safe AI research (Tesla)
- 2015: SoftBank sells Pepper robots
- 2015: OpenAI - $1B Company (Musk et al.)
- 2016: AlphaGo (Google DeepMind)
NIPS Growth (2015)

Total Registrations 3755

- Tutorials (2,584)
- Conference (3,262)
- Workshops (3,006)
Autonomous Cars

Grand Challenge 2005
Urban Challenge 2007
Self-driving Cars 2011-
Google DeepMind’s Atari Game
Facebook M (2015)
Microsoft Oxford Project AI APIs (2015)

Face APIs
  BETA
  See your users with Face Detection and Recognition

Speech APIs
  BETA
  Communicate with your users with speech recognition and synthesis powered by Bing

Vision APIs
  BETA
  Understand images and generate thumbnails

Language Understanding Intelligent Service (LUIS)
  Invite only
  Understand natural language commands tailored to your application
IBM Watson
Watson + Underarmer
OpenAI: 1 Billion Dollar Startup (2015)

Elon Musk @elonmusk - 3m
Announcing formation of @open_ai ...
openai.com/blog/introduc...
Baidu Institute of Deep Learning
(Mountain View, CA)
Toyota Invests $1B in AI (2015)
Sharp RoboHon
GM, Lyft: Self-driving Taxis (2016)
Google, Chrisler: Autonomous Minivans
Apple Siri, Google Now, Microsoft Cortana
Tay (Microsoft & Twitter)
Xiaoice: Weather Reporter Robot
Robo Advisors

Benefits of Robo Advisors

- Unbiased Advice
- No minimum Investment required
- Low Charges
- Transparency
- Customised Solutions
Robo Journalists

Narrative Science
Our technology application generates news stories, industry reports, headlines and more — at scale and without human authoring or editing.
Kulitta (Yale): Music Composition

https://www.youtube.com/watch?v=VXo-4wOb_v0
Google DeepDream
Life-Like Robots (Hanson Robotics)
Amazon Echo
Pororobot (SNU)

[Ha et al., AAAI-2015]

The ship is being pulled

1) Pororo likes cookie
2) Eddy goes
3) Petty plays

The ship is being pulled

학습 패턴 관찰에 따른 사용자 모델링

피드백
SoftBank Pepper Robot
Atlas (Boston Dynamics)

Boston Dynamics, 2016.2
3. AI Robotics Trends
Autonomous Robots

1997: Museum Tour Guide (Bonn)

2011: Kitchen Robots (TU Munich)
Healthcare Robots
Eldercare Robots
Walking Robots

Big Dog
Spot
WildCat
Atlas
Flying Robots

2008: Autonomous Helicopters

2012: Autonomous Robotic Plane

2010: Autonomous Quadroter

2015: Autonomous Drone
Self-driving Cars

Audi S8 at CES 2014

BMW Vision Next 100

Mercedes Future Truck 2025

Mercedes F015 Self-driving Car
Autonomous Driving AI

2012 Mobileye

2016 NVIDIA Deep Learning

2015 Bosch Automated Driving

2016 Ericsson + Volvo
2009: Toyota i-Real Personal Mobility

2015: Personal JetPack

2016: Intel’s Segway Personal Robot

2016: EHang Autonomous Manned Drone
4. AI and 4th Industrial Revolution
Intelligence Explosion (Good, 1965)

- Hypothesis: The smarter you are, the more creativity you can apply to the task of making yourself even smarter.
- Prediction: Positive feedback cycle rapidly leading to superintelligence.
- Extreme case of more common belief that reflectivity / self-modification is one of the Great Keys to AI.


Eliezer Yudkowsky  Singularity Institute for AI
Singularity

Exponential Growth of Computing
Twentieth through twenty first century

Calculations per Second per $1,000

All Human Brains
One Human Brain
One Mouse Brain
One Insect Brain

Level of Advancement

Rapid change in the Technological Singularity

Relatively slow change over human history

We are here (maybe)

THE SINGULARITY

Rise in human intellect could be made by integrating with machines in the future
AlphaGo and Superintelligence

- **Conventional AI**
  - 단순한 컴퓨팅 파워와 기억용량에 의존한 최적화에 기반

- **AlphaGo**
  - 딥러닝을 통해 게임의 전략까지도 학습
  - 자가학습을 통한 스스로 끊임없이 성능을 향상하는 능력
  - 인간의 단점을 극복하고 장점을 살리는 수퍼지능의 가능성을 보여주는 사례
Pepper + Watson + Google Car
4 Great Convergences

1. Human + Machine
   - Cyborgs
   - Mobile -> Wearable -> Insideable ->...

2. Software + Biology
   - Genetic engineering
   - Synthetic biology

3. Physical + Virtual
   - VR -> AR (Augmented Reality)
   - MOOCs, cryptocurrency...

4. AI + Human Intelligence
   - Deep machine learning
   - Hybrid intelligence

[David Wood, SNU talk]
Internet of Things (IoT) Communication
between man, products, systems and machines

Mass Production
pioneered by Henry Ford

Industry 1.0
Mechanical Assistance

Industry 2.0

Industry 3.0
Electronics and Control Systems

Industry 4.0
AI Clouds

Using AI Cloud APIs – No PhD Required

- Speech Recognition
- Machine Translation
- Computer Vision
- Natural Language Processing
- IBM Watson
- Machine Learning
- #deeplearningseries
IoT and AI: Smart Things

Convergent technological breakthroughs

- Internet of Things
- Smart Things
- Things instead of Strings (Semantic Web)
- Adaptive Robotics (Artificial General Intelligence)

AINL-2014, Anton Kolonin, Aigents Group
Rise of Machine Intelligence

THE SECOND MACHINE AGE
WORK, PROGRESS, AND PROSPERITY IN A TIME OF BRILLIANT TECHNOLOGIES
ERIK BRYNJOLFSSON ANDREW MCAFEE

RISE OF THE ROBOTS
TECHNOLOGY AND THE THREAT OF A JOBLESS FUTURE
MARTIN FORD
Benefits and Risks

- Safe AI Technologies
- Unemployment
- Inequality
- Threats to Human Race
AI – Engines of the 4th Industrial Revolution
ICT, AI, Smart Machines & Intelligence Information Technology

Intelligence IT
Deep Learning
Bayesian Inference
AI

Cognitive Computing
Intelligent Agents

Internet of Things
Wearable Devices
Big Data
Cloud Computing

Autonomous Vehicles
Smart Advisors
Smart Robots
Virtual Personal Assistants

ICT
Smart Machines
5. Future of AI
Humans (NI) and Machines (AI)

- Introspectionism - 1920

Environment

- Behaviorism ↔ Cybernetics 1920 - 1950

Mind (= Computer)

- Cognitivism ↔ Symbolic AI 1950 - 1980

Brain

- Connectionism ↔ Neural Nets (ML) 1980 – 2010

Body

- Action Science ↔ Autonomous Robots 2010 –

Embodied Mind | Mind Machine (= Smart Machine)
Smart Machines: 제4차 산업혁명의 엔진

Embodyedness

Mindedness
Assistants

Jarvis (Iron Man 3)
Lovers

her
love in the modern age
Caregivers

Robot & Frank (2012)
Masters

HAL (2001: A Space Odyssey)
Companions

Andrew (Bicentennial Man)
Beyond the Turing Test

Ava (Ex Machina, 2015)
Smart Machines and Machine Intelligence

**Smart Machines**

- [Super Smart TV]
- [Cloud & Big Data]
- [Smart Watch]
- [Smart Glass / VR]
- [Autonomous Cars]
- [Smart Home/Factory and IoT]

**Machine Intelligence**

- **Real-World**
- **Real-Life**
- **Real-Time**

- Multi-Sensor Streams
- Real-Life Context
- Open-Endedness

- Non i.i.d. Big Data
- Non-Stationary
- Uncertainty

- Rapid, Flexible, Robust
- Brain-Like Cognitive AI
Future: Cognitive AI

- **Narrow AI**: Follows given goals and methods.

- **AI with Deep Learning**: Works out own methods, follows given goals.

- **Human-Level AI**: Works out own goals.

- **Superhuman AI**: Free Will

- **Cognitive AI**: Agency

Timeline:
- 1980
- 1990
- 2010
- 2020
- 2030
- 2050

Modified from Eliezer Yudkowsky & David Wood