EASTASN 402A – Topics in International Technology Management
2018 Theme: Artificial Intelligence in Smart Physical Systems:
Will Asia Lead the Way?
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AI in Smart Physical Systems: Recent Developments in Asia

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Outline

- About this seminar series
- Introduction
  - Definitions
  - Introduction to our survey
- Recent developments in Asia by application domain
- Discussion

Welcome to everyone! (visitors & students for-credit)

- **Weekly public lecture / panel discussion series** presented by the **US-Asia Technology Management Center**
  - This year: 26th year of this series
  - Thursdays from today through December 6, 2018
  - See <http://asia.stanford.edu> for upcoming schedule
- **Mission:** Bring information and analysis of trends to Silicon Valley about current developments in a selected technology-intensive business area in Asia
- **Available for credit to Stanford students**
  - **EASTASN-402A "Topics in International Technology Management"**
    - Cross-listed as **EALC-402A**, **EE-402A**
    - No pre-requisites, open to undergrads and graduate students
    - May be repeated in future years for credit

Seminars 402A – Requirements for Credit

See Syllabus for official statement of credit requirements

REQUIREMENTS MAY BE DIFFERENT THAN FOR OTHER SEMINARS

A. In-person attendance at all but two sessions (e.g. 8 of 10 sessions)

- This Requirement (A) is waived for students registered through SCPD
- **Evidence of attendance is required**: today fill out survey, from next week sign weekly pass-around sheet at auditorium – no signature, no credit!

B. Submit one written comment / summary per session each week for eight (8) of the nine (9) sessions

- To me (Prof. Dasher) <rdasher at stanford dot edu>
- cc to course assistant
  Elise Jiang <ej2012 at stanford dot edu>

- Comment must provide evidence that you watched the session
- Each comment is due within two weeks of the date of the session
- See Syllabus for details on formatting, etc. (no attached files)
- **Comments for today are due by October 11, 2018**

Introduction:
Definitions and Methodology

What is AI?

- **Definition: performance by a computer (or robot or smart phone or self-driving car, etc.) of some (relatively complex) task that used to require some aspect of human intelligence**
  - Originally referred to attempts to imitate human reasoning, but now not necessarily so
  - **Multiple approaches to AI**, based on different combinations of algorithm types, e.g. Hidden Markov models, Bayesian networks, etc.
  - Usually replaces Boolean "true / false" logic by incorporating some statistically based reasoning (clustering, "fuzzy logic", etc.)
  - May (but does not necessarily) include pre-programmed representation of expert (human) knowledge as part of the software package
  - **Always includes an element of machine learning**: the computing device "learns" (becomes more accurate) by repeating similar tasks with different data or in slightly different environments

Why is AI such a hot topic now?

- **Natural next step given current state of the evolution of computing and data storage**
  - AI is enabled by drastic performance improvements and cost reductions in ...
    - Computing / processing (Moore's Law, on-chip memory)
    - Data collection, storage (in cloud), and access
  - Most current AI approaches require huge amount of shareable (i.e. online) data
- **AI provides unique insights into some types of data (may be only way to solve some kinds of analysis problems)**
  - Complex problems with many variables
- **AI is essential to complex automation problems**
  - Robotics, self-driven cars
  - Natural language interface (virtual assistants)

Artificial intelligence: a working model

- **Can be divided into several levels of task complexity**

  Perception / detection, analysis, contextualization (to the system and occasion of use), recommendation, automation

- **Always includes learning function, so that accuracy increases as the software is applied iteratively to the problem (new data each time)**

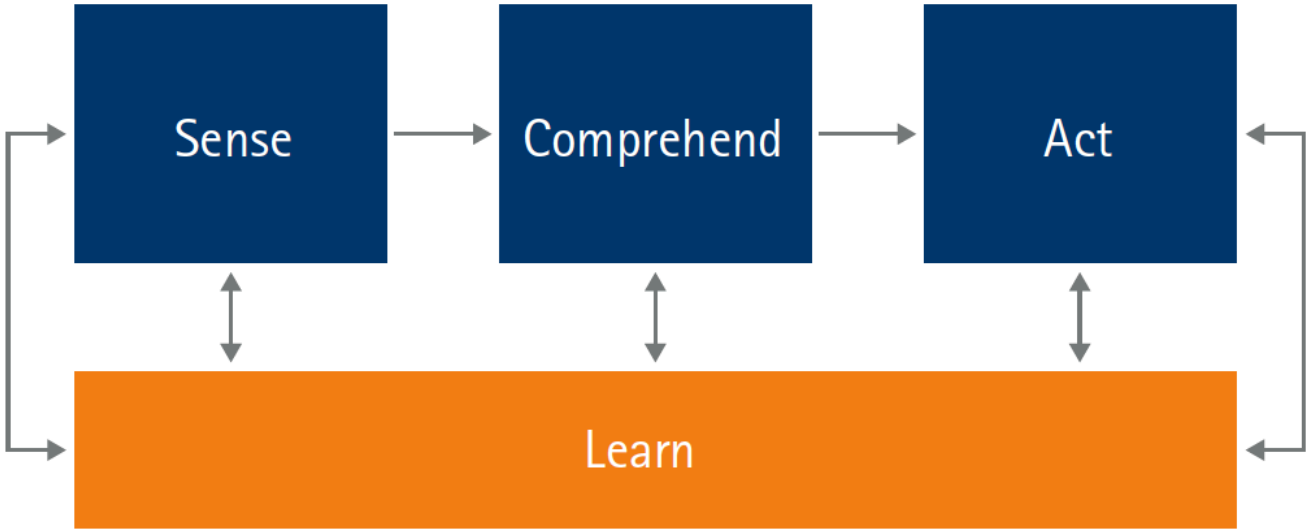


Figure from Bataller and Harris, 2016. "Turning artificial intelligence into business value. Today." Accenture. https://www.accenture.com/t20160814T215045__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Technology_11/Accenture-Turning-Artificial-Intelligence-into-Business-Value.pdf

Some AI application areas at present (a few examples)

- **Sense**
  - Computer vision
  - Cybersecurity threat detection
- **Comprehend**
  - Natural language processing
  - New medical diagnostics
  - Cybersecurity threat analysis
- **Act**
  - Smart (power) grid management
  - Virtual assistants with natural language (Siri, Alexa, Cortana, etc.)
  - Intelligent robots
  - Autonomous vehicles
  - Automated (securities) trading programs
  - Cybersecurity response automation

Topic for today: artificial intelligence in smart physical systems

Survey to investigate the extent of progress companies in Asia have made in applying artificial intelligence to "smart physical systems"

Multiple domains / industries

Get a sense of how Asia compares compare to the West

Most data gathering and first-pass analysis by two RAs in Summer 2018:

- **Daniar Imanbayev (EE)**
- **Galym Imanbayev (Med)**

Survey primarily of startup companies but also investigated relevant developments by major corporations

Our topic definition –
We surveyed companies that ...

1. **Work with and exercise a degree of control over a physical system**
    a. A physical system is not only present in the company's operation, but is part of the primary objective of the company
        i. This removes pure-play data analytics or software companies.
2. **Implement a form of artificial intelligence or autonomous decision making**
    a. Uses AI, machine learning, or deep learning to enhance/optimize a physical system.
        i. Companies with no software/decision-making involved are not included
3. **Have a close conjunction of the AI and the physical system**
    a. The more the physical system is being directly controlled by the AI portion, the better the fit.
4. **Are based or primarily operated out of a country in Asia**

Methodology

Identifying relevant startups

1. We used CBInsights' database of all companies that have *received* funding in Asia within the last 2 years.
2. We sorted this list of companies into the following categories, disregarding the rest
    a. Robotics, Industrial IIOT, Drones, Smart Cities/Buildings, Smart Construction, Auto Tech, Agriculture Tech
3. From there, we handpicked each company that displayed control of a physical system in conjunction with AI or other analytics.
    a. We excluded companies whose use of AI is strictly analytic (even if predictive) and also purely manufacturing companies

We also examined the following

1. 2016-18 market reports about cyber-physical systems
1. Asian tech news sources
2. Portfolio companies of Asia-focused institutional and corporate VCs
3. Similar info on relevant large companies and their competitors

Further evaluation of the companies (Which do we focus on for this series?)

1. **The technical innovation of the company**
   a. Judged by determining the strength/uniqueness of the technology's value offer in the context of its field, and whether the company has been holding up to that.

2. **Difference from competition**
   a. We leave out status quo companies that are "in the middle". Thus we generally pick the most proficient/prominent leaders in the field, and the small ones that are doing something that no one else is.

3. **Recent public relations**
   a. Companies that cause noticeable ripples/disruption in their field are in the press, and often reveal signs of future developments.

AI in smart physical systems: by application domain

Overview: our classification
Where AI can be found in physical systems

Written in red = covered under smart machines

- **Smart machines**
  - Robots
  - Drones
  - Automobiles
  - Virtual assistants (because of physical human interface) – not in our survey
- **IOT systems**
  - Industrial IOT
  - Smart cities / buildings
- **Smart processes**
  - Construction
  - Resource extraction (mining)
  - AgTech
  - Medicine
  - Educational tools
  - Manufacturing

Overview (1 of 3): how many Asian startup companies matched our criteria (AI in smart physical systems)

	Total Asian startups in domain (surveyed)	Asian AI startups for smart physical systems
Smart machines		
Robotics	**~ 200**	
Industrial (mfr)		**16**
Other		**11**
Drones	**88**	**8**
Automobile tech (self-driving)	**152**	**24**
Subtotal	**~ 440**	**59**

Overview (2 of 3): how many Asian startup companies matched our criteria (AI in smart physical systems)

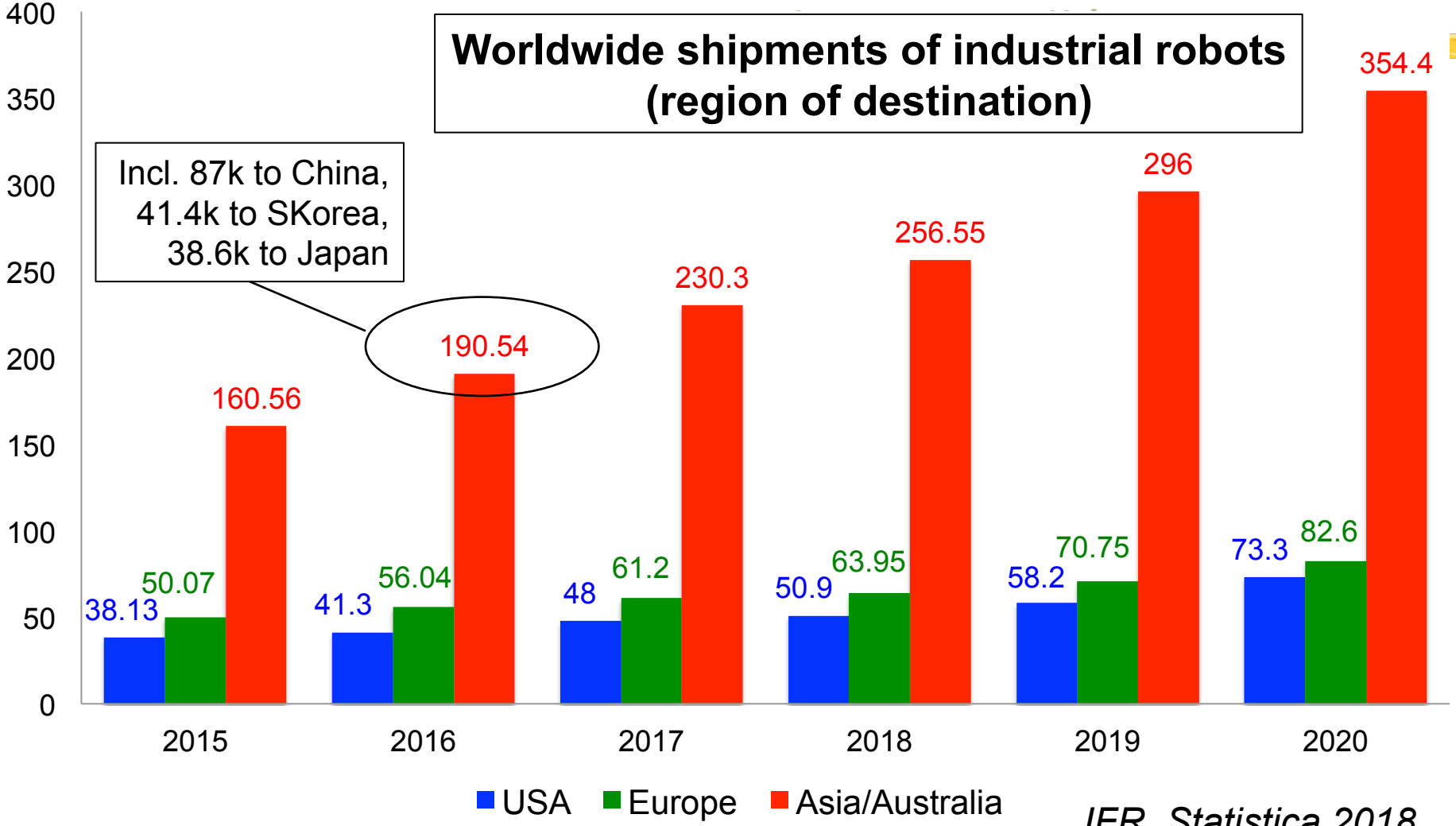
	Total Asian startups in domain (surveyed)	Asian AI startups for smart physical systems
IOT systems		
Industrial IOT	**~ 120**	**22**
Smart cities / buildings	**91**	**9**
Subtotal	**~ 211**	**31**

Overview (3 of 3): how many Asian startup companies matched our criteria (AI in smart physical systems)

Smart processes	Total Asian startups in domain (surveyed)	Asian AI startups for smart physical systems
Construction	**56**	**7**
AgTech	**62**	**10**
Subtotal	**118**	**17**
Total of all domains	**~ 770**	**107**

Comparison: https://angel.co/artificial-intelligence listed 4,731 AI startups worldwide, including purely analytics companies (6/19/2018)

Industrial robotics
A long-term area of Asia strength



IFR, Statistica 2018

Advanced industrial robotics in Asia: Drivers of growth

- **Increases in Chinese labor costs**
  - China still has lower number of robots / 10,000 workers than U.S.
  - Main providers in China are FANUC (Japan, 18%), ABB (Switz., 17%), KUKA (Ger., 15% -- bought by Midea (China) in 2017), and Yaskawa (Japan, 11%)
  - 80% of industrial robots in China are from JVs
- **Demands for rapid programming (self-learning), flexible motion**
  - To enable tasks like pick-and-place
  - To enable easier changeover of line for small-batch manufacturing
- **Cobots**
  - Robots intended to physically interact with humans in a shared workspace
  - Note that Asia was actually late to this “space”
- **Retrofitting of large installed base with new capabilities (computer vision)**

Interesting company: MUJIN (http://www.mujin.co.jp)

- **Provides robot controller that uses deep learning (AI) to replace human teaching with automated planning**
  - Claims to reduce system integration time for a pick-and-place robot from one year to two weeks
- **Founded 2011**
  - U.S. and Japanese founders (Mr. Issei Takino, Dr. Rosen Diankov)
  - Over $300M in funding so far
  - Has maintained CAGR of 258% since FY 2012
- **Controller is widely applicable to different robots**
- **Already deployed by JD.com for warehouse robot system in Shanghai**
- **Received "Emerging Leader" award in Japan – U.S. Innovation Awards (2018)**

Drones: China dominates civilian market worldwide

Top 5 Drone Brands by Global Market Share (2017)

Brand	Market Share (%)	Country
DJI	72	China
Yuneec	5	China
3D Robotics*	4	US
Parrot	2	France
Autel	2	China

Source: Skylogic Research, 2017 Drone Market Sector Report

*In August 2017, 3D Robotics announced a partnership with DJI.

- **Driver of growth: last-mile delivery**
  - Leapfrog solutions to transportation infrastructure
  - Chinese co. Ehang: a $1 billion order for 1,000 passenger drones to use for transplant organ delivery (2016) – partnering with U.S. Lung Biotechnology

Drones – government roles

- **China: relatively friendly regulatory attitude facilitates new drone applications**
  - CAAC: still cannot fly drones at night or in high wind
  - US at early stages of creating a low-level air traffic control system that would accommodate drones
  - JD.com is doing testing in Thailand and Indonesia
  - Ele.me (Alibaba's food delivery arm) gained approval in May 2018 to test drones in a large industrial zone
- **China aggressively developing military drone technologies**
  - Part of broader development of AI applications in autonomous weapons
  - Selling lower cost drones to "customers unable to afford more expensive U.S. or Israeli alternatives" (e.g. $5M versus $100M system)

Interesting company (drones): XairCraft (https://www.xag.cn/en)

- **19,999 yuan (US$3,017) Multirotor drones for cropdusting**
- Can cover large areas in a short span of time – developing AI for dusting control
- Cost advantage over traditional farming equipment
- Often, one farmer buys a drone, and local neighbors rent it from them.
- Plans to expand out of China to Japan, where local farmers are acquainted with use of advanced technologies
  - Nearly three-quarters of rice production in Japan is mechanised while over a third of rice farms made use of pesticide spraying via drones.
  - Of Japan's 2 million agricultural practitioners, more than half are aged 65 years or older, according to media reports.
- **Company Background**
  - Based in Guangzhou
  - $20M from Chengwei Capital in 2014

AI in automobile technologies

- **Areas in which U.S. is clearly ahead**
  - Number of driving hours by self-driven vehicles
  - AI capabilities, especially in hardware (e.g. computer chips for autonomous driven vehicles)
- **China coming up fast**
  - Forbes article 5/2018 predicts China will deploy self-driven cars before US
    - Massive investments in AI skills development (stated area of national priority)
    - Government approval of designated autonomous driving areas is easier than in U.S. (different regulations in different states, localities)
    - Chinese surveys report much greater trust of autonomous vehicles than in U.S. or EU and fewer concerns about ethical issues
    - Market need will grow rapidly – aging population, etc.
  - https://www.forbes.com/sites/michaelcwenderoth/2018/05/31/why-this-country-not-the-usa-will-be-first-to-adopt-driverless-cars/#2cfb90e7769a
  - Rapid growth of 5G networks in China

Interesting technology: Baidu's Apollo

http://apollo.auto

- Open source platform for autonomous vehicle software development
- 116 partners in Apollo project include Ford, Hyundai, Bosch, Nvidia, TomTom − lots of data
- Level 4 automation
- Udacity is partnering to offer education in Apollo for developers

- Partnering with Pand-auto ride sharing service in Chongqing, also driverless mini-bus system in China
- Partnering with Softbank to launch in Japan in 2019

Competition among Baidu-spinoff autonomous vehicle startups in China

- **Pony.ai (founded 2016) -- early self-driving taxi services (Series A: $112M, total funding $214M)**
  - Nansha Island, Guangzhou, 2/2018
  - Shanghai, 3/2018
  - Has T3 license for testing in Beijing
- **Roadstar.ai (from 2017, total funding $138M)**
  - CTO worked at Baidu, Tesla, Google
- **JingChi (from 2017, $56M)**
  - Founder from Baidu led to lawsuit by Baidu, now founder is out

Industrial IOT

- **Factory (and warehouse) automation beyond individual robots**
  - Device interconnection via the cloud (Industry 4.0)
  - Synchronization of robots, automated information into supply chain
- **Geographic distribution of the 22 companies we selected for survey**
  - China: 7
  - Japan: 6
  - India: 4
  - Israel: 4
  - South Korea: 1
- **Market drivers**
  - Malfunction prediction & maintenance scheduling
  - Improving efficiency

Interesting company: Intelligent Edge System LLC

- **Joint venture in Japan between three Japanese companies announced January 2018, operational from April 2018**
  - FANUC (robots)
  - Hitachi Ltd. (software control systems and other operational technology)
  - Preferred Networks (PFN, an AI unicorn)
- **"Use AI as an intermediary between the Cloud and edge devices such as machine tools, industrial machinery, and robots to achieve cyclic, real-time control"**
- **Still no website that I could find (9/27/2018)**
- **President is former EVP from Hitachi**

Smart cities and buildings

- **Navigant (2016) predicted global smart city revenue to grow from $36.8 billion in 2016 to $88.7 billion by 2025**
- **Major investments in Asia for quite some time**
  - In 2012, projects underway included Fujisawa (Japan), Songdo IDB (S. Korea), and 36 cities in China
  - China plans for 200 smart city pilot projects
- **Early drivers: energy efficiency, transportation improvements**
- **More recently: public safety (e.g. AI for surveillance and analysis in China)**
- **Individual cities leading in smart city investments: Singapore, Tokyo, London, New York, London, and Shanghai**

Interesting company: Kuang-Chi Group

http://www.kuang-chi.com/en/

- **Founded 2010 by Ruopeng Liu ("the Chinese Elon Musk")**
  - Umbrella over multiple Kuang Chi companies (similar to a Keiretsu)
  - Has received at least $300M in funding so far
- **July 11, 2018: Kuang-Chi signed a cooperation framework agreement with the Shanghai Security Service Corp.**
  - Kuang Chi will make helmets for the Security Service using metamaterials and IoT-infused Camera systems
  - Most likely to be used in conjunction with a smart city/police force
  - No oher details revealed, but expect patenting forthcoming
- **Early July 2018, Kuang-Chi partnered with Xihu New Energy Transportation Development**
  - To create ultra-light internal frameworks for new energy vehicles
  - 50-50 joint venture

General trends about AI in Asia

- **Very hot topic**
- **Massive investments in most Asian countries**
  - China in lead: has made AI a national priority, aims to have parity with U.S. by 2020 and be world leader in 2030
  - S. Korea pledges to be in Top 4 by 2022, has invested $2bn in AI R&D and plans even more by 2022 https://www.forbes.com/sites/cognitiveworld/2018/09/07/is-south-korea-poised-to-be-a-leader-in-ai/#35850da7fa2f
  - Japan AI market (total, including analytics) predicted to grow from about $34 billion (2015) to over $750 billion (2030), with the transport sector accounting for about $275 billon https://medium.com/neuromation-io-blog/artificial-intelligence-in-japan-r-d-market-and-industry-analysis-e086a38639ec
- **Still talent gap: US in the lead**
  - But strong educational programs across Asia in the basic math & CS

Summary and final remarks

- **Title of this series: "Will Asia take the lead?"**
- **More interesting questions:**
  - What areas will be the application domain targets for using AI in different Asian economies?
  - How will Asia countries develop different policies and institutional frameworks to support the innovation around AI?
  - How can U.S. businesses take advantage of the opportunities that are emerging?
- **We'll start to look at these issues from next week!**