Regulatory Science of AI Based Medical Systems

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AI ?

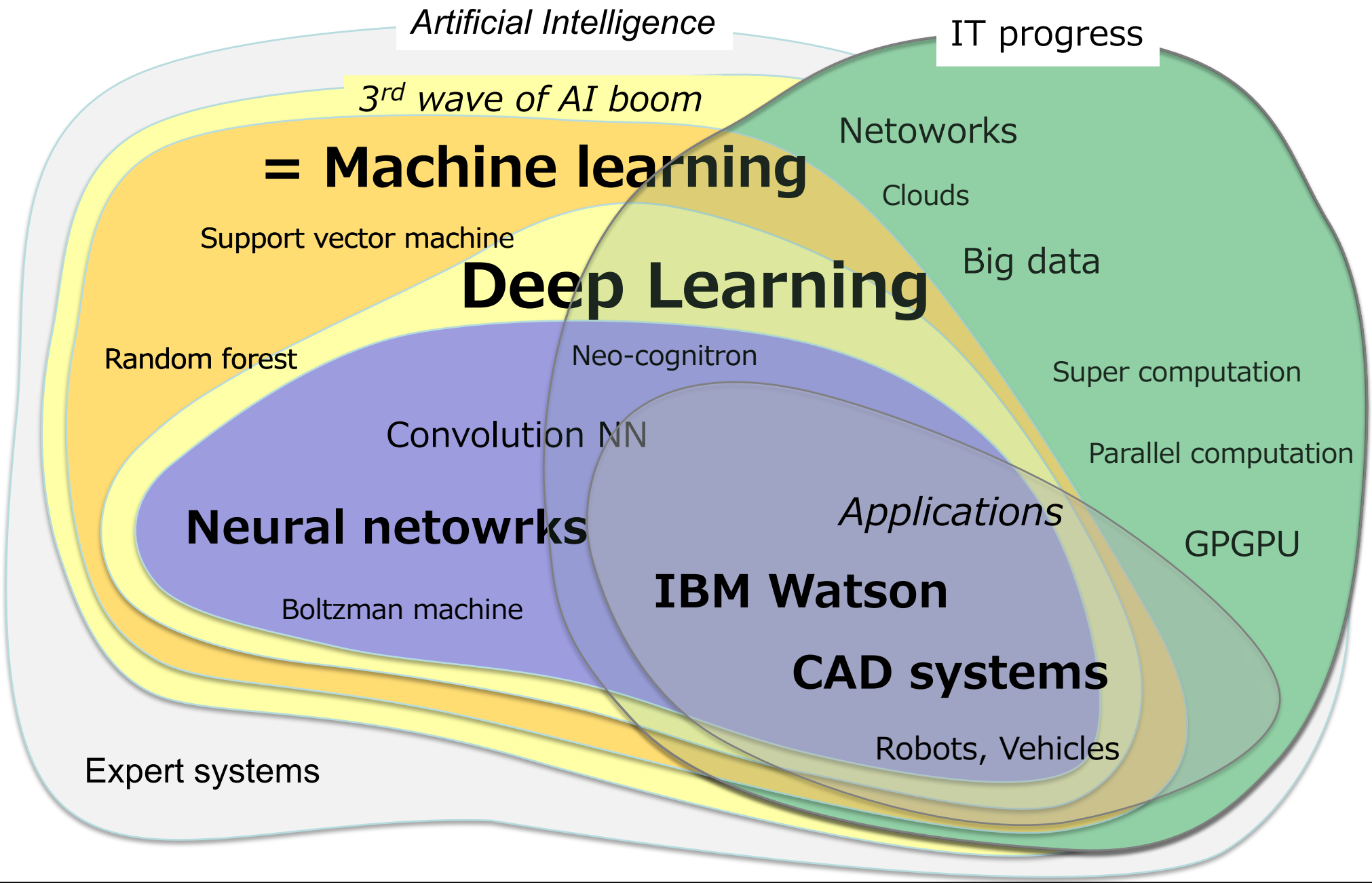


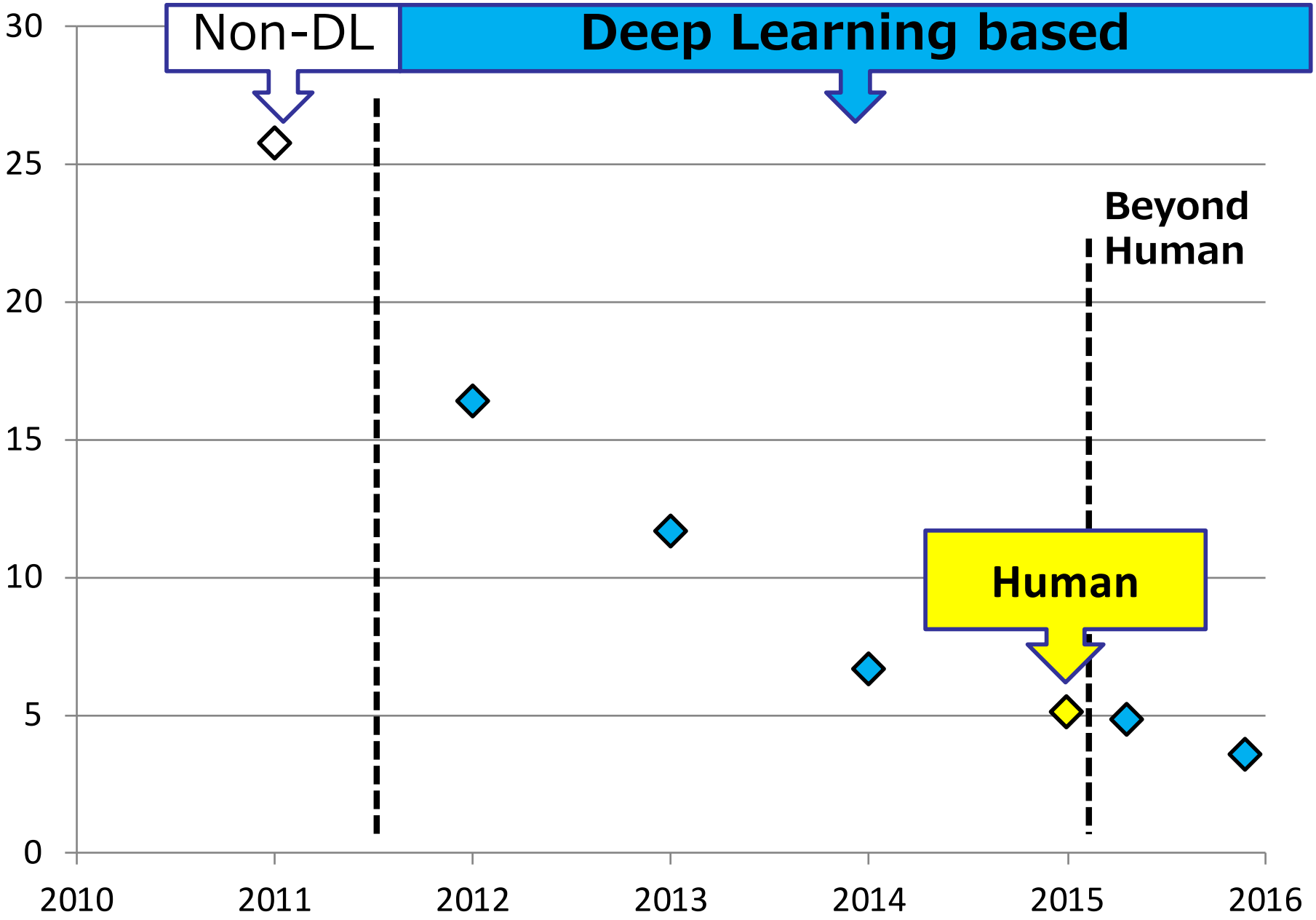
Image recognition *was* difficult…

Write how to distinguish dog and cat.

- You can't write using natural language.
- But 3 year old kid can tell.

Deep learning solved this problem!

Error rates improves



AI in medical applications

- Image recognition – computer assisted diagnosis
- IBM Watson - Literature search assistance

More applications in research...

- Hyper-resolution of CT
- Image conversion (CT⇄MRI)
- Image segmentation/classification/registration
- Clinical decision making

Approved AI: FDA

2017/1	**Caldio DL** (Arterys Inc.)	CAD to analyze cardiac MR images by deep learning.
2018/2	**ContaCT** (Viz. AI.)	CAD to detect possible infarctions of major cerebral arteries.
2018/3	**Acumen HPI** (Edwards Lifescience)	Alert low blood pressure during surgery by machine leaning.
2018/4	**IDx-DR (IDX LLC)**	**World's first automated diagnosis software to diagnose retina images.**
2018/5	**OsteoDetect** (Imagen)	CAD to detect bone fracture from stereo X-ray images.

CAD: Computer Assisted Diagnosis. NOT automated disgnosis.

Regulation & guidance on AI

中国	• CAD classification extended to accept AI in Sep. 2017. • Tensent 騰訊覓影 started from June 2018. （Nikkei Xtrend 2018/7/4）
USA	• Approved as ‘de Novo.’ • Several draft guidance on CAD. • No guidance on machine learning.
EU	• Decision Support Software mentioned in SaMD guidance. • A few CE certifications.
Korea	• Guidance issued. One approval.
Japan	• Endoscopic CAD approval soon?

（テンシュンミーイン）

PMDA "AI-based med-sys" report

Advanced Biomedical Engineering
7: 118–123, 2018.

Invited Review Paper

DOI:10.14326/abe.7.118

Regulatory Science on AI-based Medical Devices and Systems

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https://doi.org/10.14326/abe.7.118

Full report in Japanese
https://www.pmda.go.jp/rs-std-jp/outline/0003.html

Unique 4 characters of AI med-sys

1. **Plasticity**
   - Performance can transform by continuous learning.
   - Transformation can be regulatory concerns.
2. **Unpredictability (black-box)**
   - Output of neural network is hard to predict.
3. **Autonomy (in future)**
   - Transform relations between patient and doctor.
4. **Data quality**
   - Data as fuel and ingredients.

Performance transformation by continuous learning

- Pros
  - Customization for region.
  - Differentiate hospitals.

- Cons
  - Transformation can be negative.
  - Site-wise variations make quality control and adverse event measures difficult.

Continuous learning without the ground truth can be costly.

Unpredictability (black box)

2016/03

- 4 wins – 1 lose... Bad game.
- Alpha couldn't explain why AI behaved so.
- Neural network is not always predictable.

Visualization of factors that strongly influence output – Hot topic

Level of CAD CAD = Computer Assisted Diagnosis

CAD Level 1	CAD calculates feature value(s) related to a disease (e.g. likelihood of a cancer, tumor diameter) to assist diagnostic decision.
CAD Level 2	CAD calculates a diagnostic suggestion (e.g. malignancy, staging) to assist the diagnostic decision or to prevent oversights. **IDx-DR**
CAD Level 3	CAD processes images and information (can be multimodal) and presents a comprehensive diagnosis to doctors to assist the diagnostic decision.
CAD Level 4	CAD processes multimodal information and provides an automated diagnosis to doctors. The doctors must review and approve the diagnosis.
CAD Level 5	CAD processes multimodal information and provides a fully automated diagnosis without doctors' intervention and review.

SCIENCE ROBOTICS | EDITORIAL

ROBOTS AND SOCIETY

Medical robotics—Regulatory, ethical, and legal considerations for increasing levels of autonomy

Guang-Zhong Yang, James Cambias, Kevin Cleary, Eric Daimler, James Drake, Pierre E. Dupont, Nobuhiko Hata, Peter Kazanzides, Sylvain Martel, Rajni V. Patel, Veronica J. Santos, Russell H. Taylor

Level of autonomy of medical robots (Fig. 1)

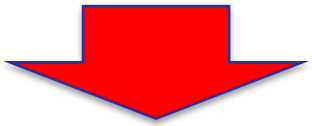
No autonomy	Operator performs all tasks, including monitoring, decision making and execution.
Robot assistance	Operator maintains continuous control, and robot provides certain assistance.
Task autonomy	Operator maintains control of the system, and robot can perform operator-initiated tasks.
Conditional autonomy	Operator selects and approves plan, and robot performs it under close human oversight.
High autonomy	Robot can make decision but under supervision of qualified operator.
Full autonomy	No human needs to be in the loop, and robot can perform an entire surgery.

Data quality issue

- Learning data
  - Machine learning
  - Parameter tuning
- Testing data
  - Clinical trial data
  - Validation

DON'T MIX THEM

- Many available algorithms learning while solving.



- 'Rewind' the AI back to previous state before solving the test data.
- QA system to shutdown accidental mixture.

AI and risk

AI level does not directly correlate to risk level.

- No new hazard added by AI.
- Scenarios to hazardous situation can complicate.

cf: Degree of autonomy does not directly correlate to risk level. (IEC TR 60601-4-1)