CEMP

APPLICATIONS OF ARTIFICIAL INTELLIGENCE FOR HEALTH

Week 2

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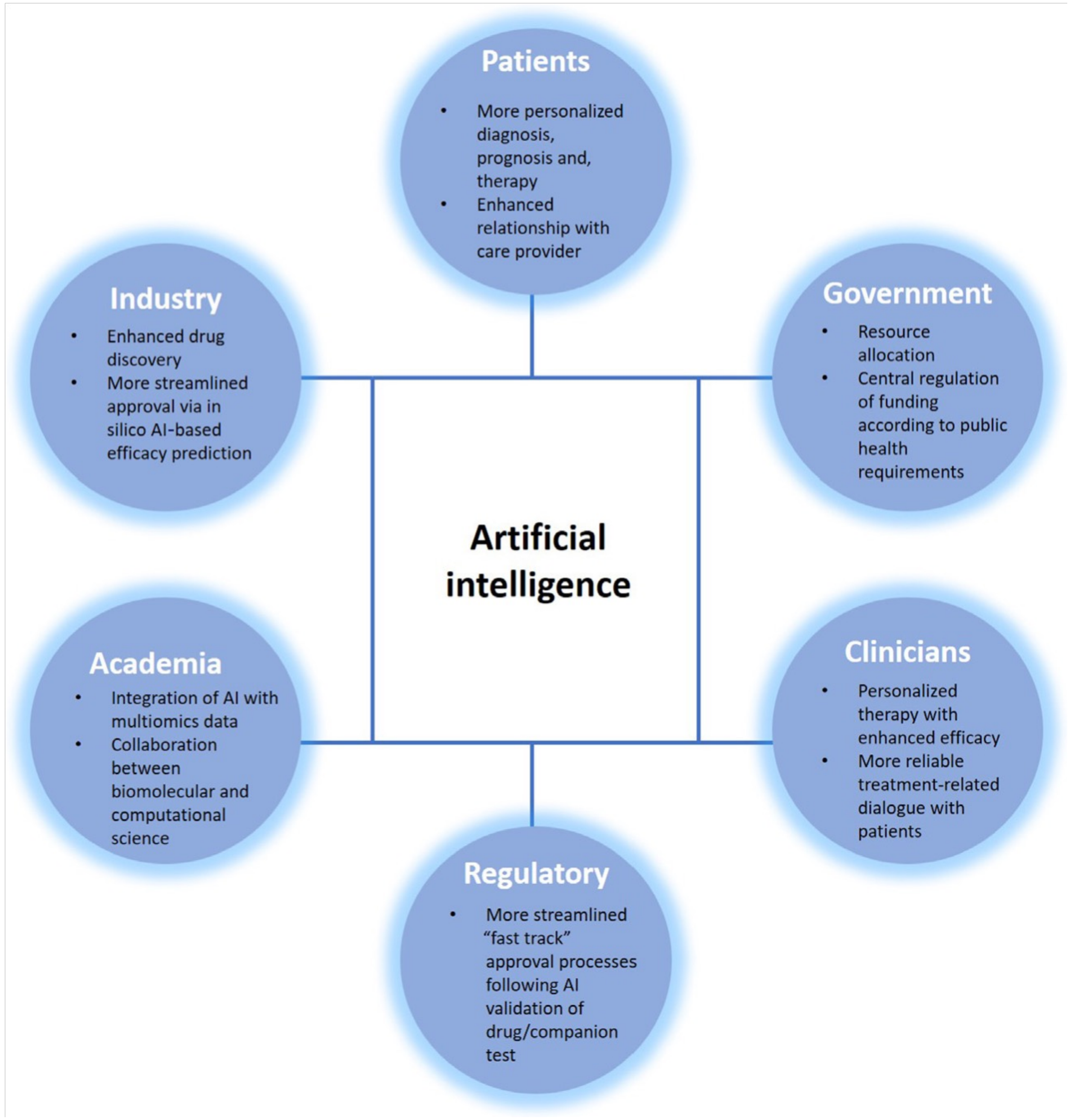
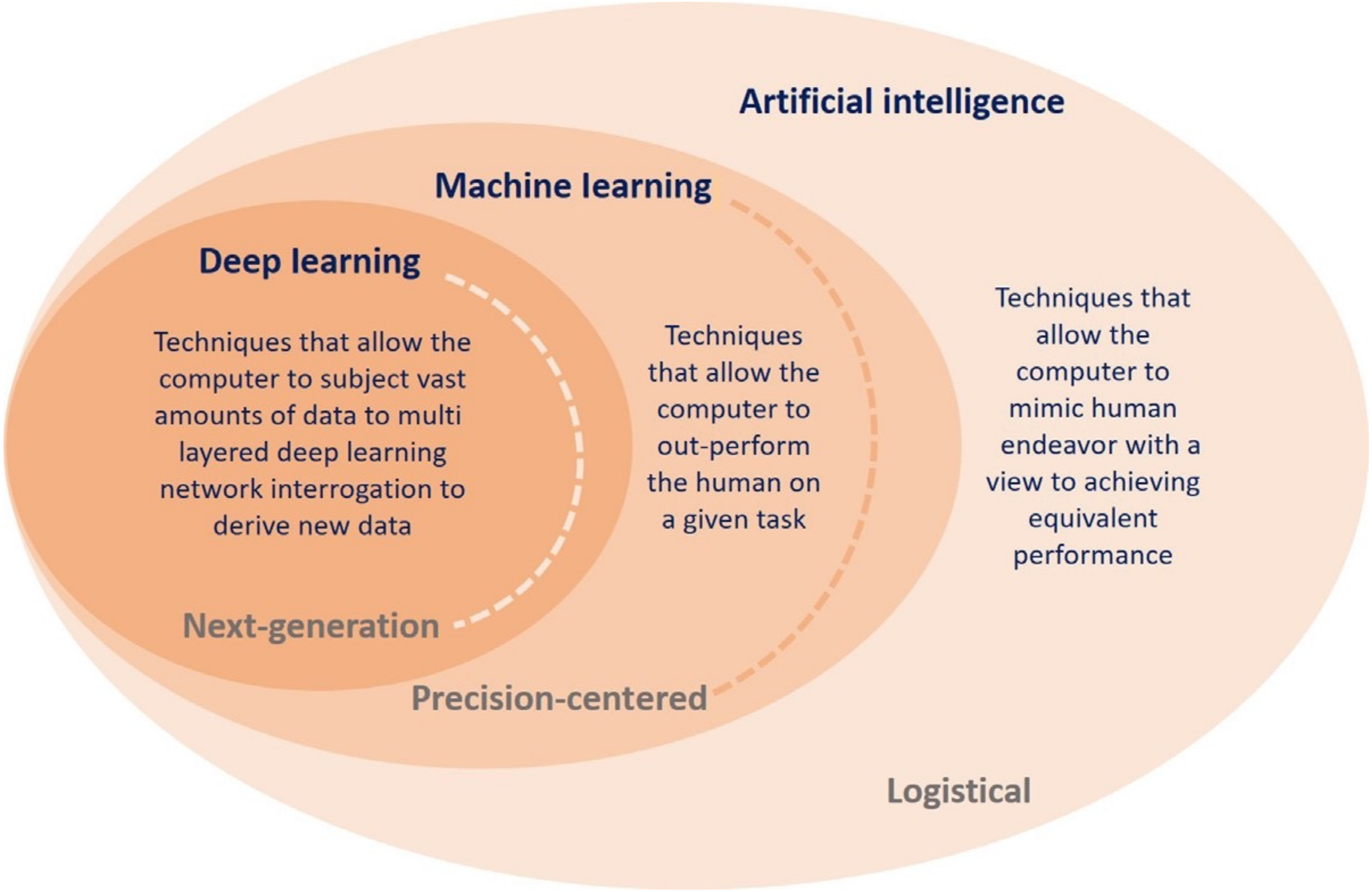
Cancer diagnostics and treatment decisions using artificial intelligence

- Artificial intelligence, machine learning, and deep learning in CANCER
- Artificial intelligence to determine cancer susceptibility
- Artificial intelligence for enhanced cancer diagnosis and staging
- Artificial intelligence to predict cancer treatment response
- Artificial intelligence to predict cancer recurrence and survival
- Artificial intelligence for personalized cancer pharmacotherapy

Artificial intelligence, machine learning, and deep learning in cancer



Artificial intelligence, machine learning, and deep learning in cancer



Artificial intelligence to determine cancer susceptibility

Aiko is 38 years of age and **has a strong family history of colorectal cancer**. At the insistence of her family, she agrees to go and see a gastroenterologist following several episodes of fresh rectal bleeding and mild unintentional weight loss. **The colonoscopy demonstrates an impassable malignant-looking structure in the sigmoid colon, which is subsequently confirmed as adenocarcinoma on histology**. Her staging CT scan reveals two metastatic deposits in the liver. She undergoes treatment in the form of systemic chemotherapy, right hemi-hepatectomy, and colorectal resection of her primary tumor. She is now under a strict 6 monthly surveillance program as her oncologist tells her that she is still at risk of cancer relapse, given her advanced stage at presentation. **She asks her cancer physician whether more could have been done at an earlier stage to identify and quantify her risk of cancer, given the family history**.

Kim BJ, Kim SH. Prediction of inherited genomic susceptibility to 20 common cancer types by a supervised machine-learning method. Proc Natl Acad Sci USA 2018;115(6):13227

Rau HH, Hsu CY, Lin YA, Atique S, Fuad A, Wei LM, et al. Development of a web-based liver cancer prediction model for type II diabetes patients by using an artificial neural network. Comput Methods Prog Biomed 2016;125:5865

Simon G, DiNardo CD, Takahashi K, Cascone T, Powers C, Stevens R, et al. Applying artificial intelligence to address the knowledge gaps in cancer care. Oncologist. 2019;24:77282

Artificial intelligence for enhanced cancer diagnosis and staging

Penny is a 40-year-old telecommunications executive who has recently been diagnosed with breast cancer. Her surgeon councils her about the treatment options and it is recommended that she undergoes a sentinel lymph node biopsy (SLNB) before deciding whether or not to proceed to more radical surgical axillary nodal clearance. Biopsy tissue acquired at the time of SLNB is sent to the histopathologist who subjects the slides to hematoxylin and eosin (H&E) staining, as well as immunohistochemical analysis. **The verdict based on pathologist evaluation is that her nodes are free of cancer invasion**. However, **Penny's cancer physician has also enrolled her to a new trial evaluating the application of deep learning algorithms in detecting lymph node metastases in women with breast cancer. On AI-based analysis, her tissue sections are considered to be cancer bearing**. She decides to undergo the more radical treatment option and currently remains in remission.

Ehteshami Bejnordi B, Veta M, Johannes van Diest P, van Ginneken B, Karssemeijer N, Litjens G, et al. Diagnostic assessment of deep learning algorithms for detection of lymph node metastases in women with breast cancer. JAMA. 2017;318 (22):2199210.

Esteva A, Kuprel B, Novoa RA, Ko J, Swetter SM, Blau HM, et al. Dermatologistlevel classification of skin cancer with deep neural networks. Nature. 2017;542 (7639):11518.

Artificial intelligence to predict cancer treatment response

Tomas is a 58-year-old university lecturer from Stockholm who **has recently been diagnosed with a locally advanced rectal cancer**. Preoperative imaging shows no evidence of distant site metastases, but pelvic MRI reveals that the primary tumor is bulky and extends to the predicted margin of surgical resection. As per conventional practice, it is suggested that Tomas undergoes pelvic radiotherapy, with a view to down-sizing the primary tumor and improving the likelihood of achieving complete surgical tumor clearance, with cancer-free margins of excision. **Tomas receives** 50.4 Gy of pelvic **radiotherapy** in divided fractions and then undergoes repeat imaging 10 weeks later to assess tumor response. Unfortunately, his tumor has shown no signs of meaningful regression and now appears to have spread to the liver and lungs. Tomas is bitterly disappointed and wants to know why he was put forward for radiation therapy if it was not going to work?

Typical questions in radiation oncology include "what is my risk of treatment-related toxicity?", "what is the likelihood of achieving a good local response?," and "will my tumour spread elsewhere while I am being treated?"

Toratani M, Konno M, Asai A, Koseki J, Kawamoto K, Tamari K, et al. A convolutional neural network uses microscopic images to differentiate between mouse and human cell lines and their radioresistant clones. Cancer Res 2018;78(23):67037.

Liu R, Zhang G, Yang Z. Towards rapid prediction of drug-resistant cancer cell phenotypes: single cell mass spectrometry combined with machine learning. Chem Commun 2019;55(5):61619.

Huang C, Clayton EA, Matyunina LV, McDonald LD, Benigno BB, Vannberg F, et al. Machine learning predicts individual cancer patient responses to therapeutic drugs with high accuracy. Sci Rep 2018;8(1):16444.

Huang C, Mezencev R, McDonald JF, Vannberg F. Open source machine-learning algorithms for the prediction of optimal cancer drug therapies. PLoS One 2017;12 (10):e0186906.

Artificial intelligence to predict cancer recurrence and survival

Feroz is a 62-year-old retired mechanical engineer who **was diagnosed with colon cancer in 2011**. His surgical oncologist subjected him to a full raft of investigations before offering surgery, which took the form of a laparoscopic right hemicolectomy. His resection specimen revealed a completely excised Stage I tumour of the ascending colon. His case was discussed at the colon cancer multidisciplinary meeting, and given the favourable pathology, he was not felt to require adjuvant chemotherapy. He underwent yearly CT scanning and follow-up and was told by his physician in 2016, that having completed 5 years of follow-up, and having remained recurrence free, he would be discharged from further routine surveillance as this was not indicated. **In May of 2018**, Feroz sees his doctor for unintentional weight loss and a CT scan is arranged. This reveals **a lesion in the right lung, which is subsequently confirmed on biopsy as a colon cancer metastasis**. **Feroz and his family are confused; they were told to complete 5 years of follow-up, which they did, and cannot understand why this has happened**.

Zhang Y, Li H, Zhang W, Che Y, Bai W, Huang G. LASSO based CoxPH model identifies an 11 lncRNA signature for prognosis prediction in gastric cancer. Mol Med Rep 2018;18(6):557993.

Exarchos KP, Goletsis Y, Fotiadis DI. Multiparametric decision support system for the prediction of oral cancer reoccurrence. IEEE Trans Inf Technol Biomed 2012;16 (6):112734.

Park C, Ahn J, Kim H, Park S. Integrative gene network construction to analyze cancer recurrence using semi-supervised learning. PLoS One 2014;9(1):e86309.

Hasnain Z, Mason J, Gill K, Miranda G, Gill IS, Kuhn P, et al. Machine learning models for predicting post-cystectomy recurrence and survival in bladder cancer patients. PLoS One 2019;14(2):e0210976.

Artificial intelligence for personalized cancer pharmacotherapy

In broad terms, the application(s) are likely to fall under three main headings:

(1) drug selection and toxicity prediction;
(2) drug pairing; and
(3) drug repurposing.

Bloomingdale P, Mager DE. Machine learning models for the prediction of chemotherapy-induced peripheral neuropathy. Pharm Res 2019;36(2):35.

Xia F, Shukla M, Brettin T, Garcia-Cardona C, Cohn J, Allen JE, et al. Predicting tumor cell line response to drug pairs with deep learning. BMC Bioinforma 2018;19 (Suppl. 18):486.

Iorio F, Bosotti R, Scacheri E, Belcastro V, Mithbaokar P, Ferriero R, et al. Discovery of drug mode of action and drug repositioning from transcriptional responses. Proc Natl Acad Sci USA 2010;107(33):146216.

Cheng F, Liu C, Jiang J, Lu W, Li W, Liu G, et al. Prediction of drug-target interactions and drug repositioning via network-based inference. PLoS Comput Biol 2012;8(5):e1002503.