(Biased) Overview of A.I. Topics

David I. Inouye
High-Level Categorization of AI Topics

1. Artificial Intelligence (other than topics below)


3. Computer Vision

4. Natural Language Processing
1. Artificial Intelligence (Based on AAAI topic list)

- Cognitive modeling and systems
- Constraint Satisfaction/ Optimization
- Game theory
- Human + AI
- Knowledge representation and reasoning
- Robotics
AI: Cognitive Modeling

- Models of human/animal cognition
- Based on psychological theory and experiments

2 Goals

- AI -> Cognitive Science: Understand/test underlying cognitive mechanisms by computational modeling

- Cognitive Science -> AI: Improve computational methods via insights from cognitive science
AI: Constraint Satisfaction / Heuristic Optimization

- Eight queens puzzle
- Map coloring problem
- Real-world
  - Resource allocation
  - Scheduling
AI: Game Theory

- Prisoner’s dilemma

![Prisoner's Dilemma Diagram]

- Real-world
  - Google Ads bidding
  - Connections to “Generative Adversarial Networks”
AI: Human + AI

- Crowdsourcing
  - “Stop spam, read books”

- Human-robot interactions

AI: Knowledge representation and reasoning

- Knowledge graphs
  - Spock played characterIn Star Trek
  - Spock starredIn Leonard Nimoy
  - Science Fiction genre Star Trek
  - Star Wars starredIn Alec Guinness
  - Obi-Wan Kenobi played characterIn Alec Guinness

- Inferences in knowledge graphs
  - Did Alec Guinness ever play a Science Fiction character?

2. Machine Learning (based on NeurIPS Topics)

- Learning with limited labels
- AutoML / Meta-learning
- Generative / probabilistic models
- Reinforcement learning
- Explainable AI
- Domain Generalization
ML: Learning with limited labels

▶ Active learning

▶ Few-Shot Learning

https://medium.com/sap-machine-learning-research/deep-few-shot-learning-a1caa289f18

https://blog.cloudera.com/a-guide-to-learning-with-limited-labeled-data/
ML: AutoML / Meta-learning

https://cloud.google.com/automl-tables/?hl=vi
ML: Generative/Probabilistic Models

- Density estimation
- Graphical Models

The Student Network

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ML: Topic Models

ML: Generative Adversarial Networks (GAN)

- Generative Adversarial Networks (GAN)

![Image](http://openaccess.thecvf.com/content_cvpr_2017/papers/Isola_Image-To-Image_Translation_With_CVPR_2017_paper.pdf)

- Image to image translation via GANs

![Image](http://papers.nips.cc/paper/5423-generative-adversarial-nets.pdf)
ML: Invertible networks

- Invertible Flows

- Deep Density Destructors
ML: Reinforcement Learning

- Game playing

- Bandit algorithms (simpler form of RL)
  - Which Google search result should I show?
ML: Explainable AI

Why model explanations?
Accuracy is insufficient for many applications

- Loan approval: “Could the model make a catastrophic mistake?”
- Self-driving cars: “Does the model obey common sense intuitions?”
- Bail decisions: “Is the model biased because of historical discrimination?”
- Healthcare: “Does the model agree with doctor’s knowledge?”
- Military strategy: “How will the model perform in adversarial settings?”
ML: Domain Generalization

Distribution shifts in the real-world

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<th>Dataset</th>
<th>Domain generalization</th>
<th>Subpopulation shift</th>
<th>Domain generalization + subpopulation shift</th>
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Input (x):
- Camera trap photo
- Tissue slide
- Cell image
- Molecular graph
- Wheat image
- Online comment
- Satellite image
- Satellite image
- Product review
- Code

Prediction (y):
- Animal species
- Tumor
- Perturbed gene
- Bioassays
- Wheat head bbox
- Toxicity
- Land use
- Asset wealth
- Sentiment
- Autocomplete

Domain (d):
- Camera
- Hospital
- Batch
- Scaffold
- Location, time
- Demographic
- Time, region
- Country, rural-urban
- User
- Git repository

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Train example:
- Images of animals, tissues, molecules, and data.

Test example:
- Images of data in different domains.

Adapted from:
- Beery et al. 2020
- Bandi et al. 2018
- Taylor et al. 2019
- Hu et al. 2020
- David et al. 2021
- Borkan et al. 2019
- Christie et al. 2018
- Yeh et al. 2020
- Ni et al. 2019
- Raychev et al. 2016

How can you train models so that they work in new unseen test domains?

3. Computer Vision (Based on CVPR sessions)

- Classic tasks
  - 3D Multiview / Depth estimation
  - Synthesis
CV: Classic Tasks

- Recognition

- Segmentation


http://vladlen.info/publications/feature-space-optimization-for-semantic-video-segmentation/
CV: 3D Multiview / Depth estimation

https://vision.in.tum.de/research/image-based_3d_reconstruction/multiviewreconstruction

CV: Image / Video Generation (Synthesis)

▸ Style transfer


▸ Sketch to draw

4. Natural Language Processing (based on ACL 2019 Call for Papers (CFP))

- Tagging and Parsing
- Information Extraction and Text Mining
- Dialogue Systems / Question Answering
- Applications
  - Summarization
  - Sentiment Analysis
  - Machine Translation
NLP: Ambiguity is huge challenge in NLP

Lexical Ambiguity
The presence of two or more possible meanings within a single word.

"I saw her duck."

Syntactic Ambiguity
The presence of two or more possible meanings within a single sentence or sequence of words.

"The chicken is ready to eat."

https://www.thoughtco.com/ambiguity-language-1692388
NLP: Tagging and Parsing

Diagram showing the tagging and parsing of the sentence: "Bob made a book collector happy the other day."
NLP: Information Extraction and Text Mining

Text in
- Brazil ranks number 5 in the list of countries by population.
- The term “Ibu Negara” (Lady/Mother of the State) is used for wife of the President of Indonesia.
- Game of Thrones is an adaptation of A Song of Ice and Fire, George R. R. Martin’s series of fantasy novels. It ranks fourth among the IMDB Top Rated TV Shows.

Data out
- **THE COUNTRIES WITH THE LARGEST POPULATION**
  - China: 1,388,232,693
  - India: 1,342,512,706
  - United States: 326,474,013
  - Indonesia: 263,510,146
  - Brazil: 174,315,386

- **THE COUNTRY’S FIRST LADIES**
  - Brigitte Macron
    - Spouse: Emmanuel Macron, President of France (2017 - )
  - Melania Trump
    - Spouse: Donald J. Trump, U.S. President (2017 - )
  - Irina Widodo
    - Spouse: Joko Widodo, President of Indonesia (2014 - )

- **IMDB TOP RATED TV SHOWS**

[https://www.ontotext.com/knowledgehub/fundamentals/information-extraction/](https://www.ontotext.com/knowledgehub/fundamentals/information-extraction/)
NLP: Dialogue Systems / Question Answering

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