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CSCE 240: Advanced Programming Techniques
Lecture 24: Intro to AI / ML/ DL

PROF. BIPLAV SRIVASTAVA, AI INSTITUTE

6TH APRIL 2023

Carolinian Creed: "I will practice personal and academic integrity."

Credits: Some material reused with permission of Dr. Jeremy Lewis. Others used as cited with thanks.

Organization of Lecture 24

- Introduction Section
  - Recap of Lecture 23
  - News / announcements / clarifications

- Main Section
  - Concept: AI as decision support tool
  - Concept: ML and DL
  - Perspective: Successful AI, AI for Society
  - Concept: AI in Software Development
  - Task: HW 6 – due today
  - Task: Project – PA #6 starts
- Concluding Section
  - About next lecture – Lecture 25
  - Ask me anything

Introduction Section

Recap of Lecture 23

- Programming practice for project assignments based on PA#4
- We discussed
  - Templates
  - Class templates
  - Functional templates
- PA#5 is due today

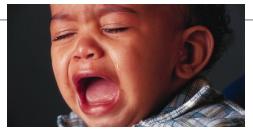
Announcement

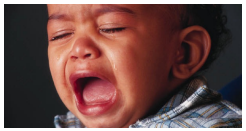
- McNair Junior Fellows program: **30 grantees** this summer, and we sure hope you can encourage your students to explore this opportunity. All details and applications are on: http://www.cec.sc.edu/mjf | **Deadline April 21st, 2023 !**
  - The program, in its 9th year since its foundation, and in its 5th year as an official CEC program, provides supports for undergraduate students up to 3k$ in summer funds and runs activities that helps the students further explore research (as well as research posters, state of the art and other research initiation programs).
    Contact: Ramy Harik
- Summer Internships
  - You can apply to fellowship and work with faculty ON YOUR IDEA
  - You can work with faculty ON THEIR IDEA and get paid
  - You can work on your idea with a faculty to mentor (with/ without fellowship)

Main Section

Concept: AI

Example: Taking Care of a Baby
Individual's Extension





Agent

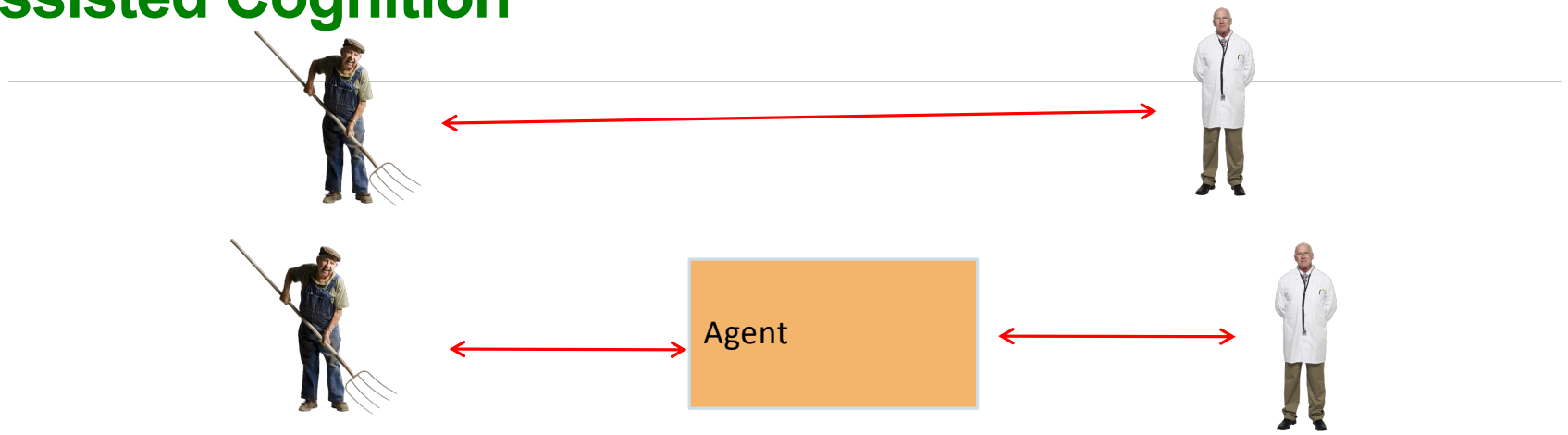
Expected behavior:

- Inform
  - Alert when crying
  - Alert when awake
  - Alert when idle
- Do
  - Raise temperature of room
  - Play music
  - …

Conditions can be

- input and **reasoned** (**e.g. rule-based methods**) OR
- **learned** **(from data)**

Example: Taking Care of a Senior
Assisted Cognition



Expected behavior:

- Inform
  - Alert when idle
  - Alert when away from known locations
  - Alert when checkup/ medicines due
- Do
  - Send body parameters periodically
  - …

Example: Taking Care of Oneself
Personal Digital Assistants

Agent

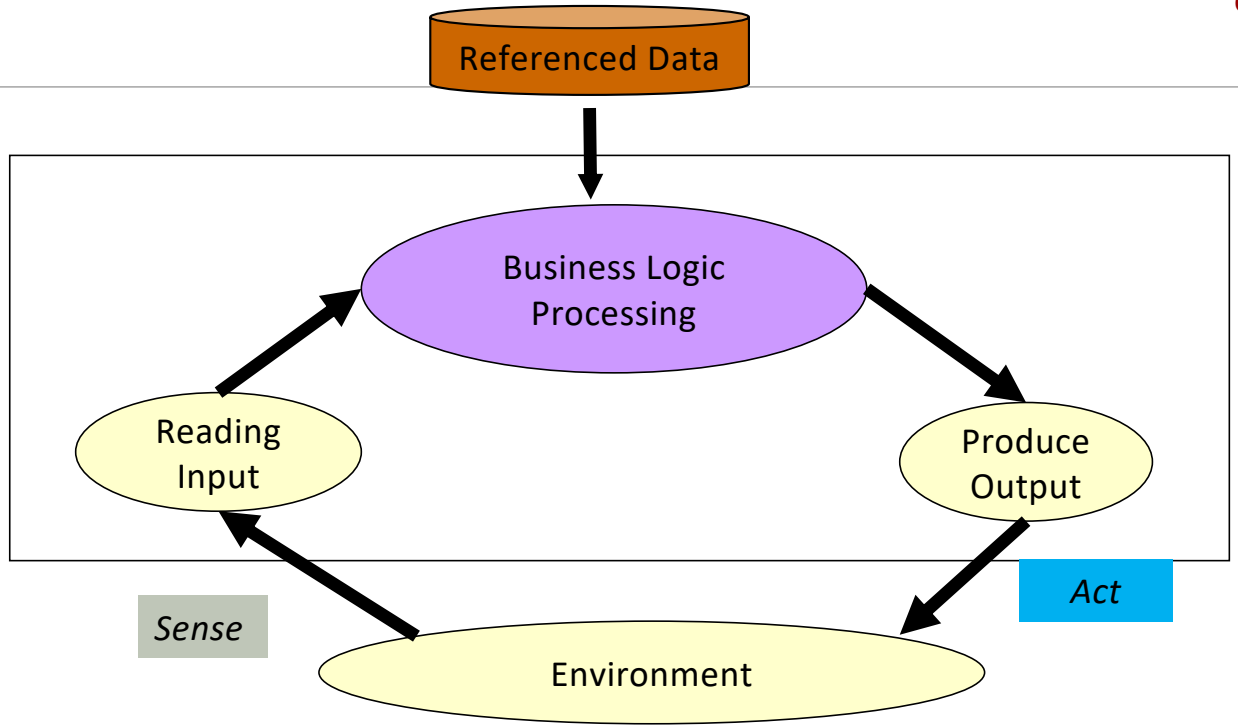
Expected behavior:

- Inform
  - When missing meetings
  - When missing social commitments
  - Reminding of priorities
  - …
- Do
  - Make all cancellations / re-bookings when schedule changes
  - Find alternatives to current decisions and give choices (e.g., traffic)
  - …

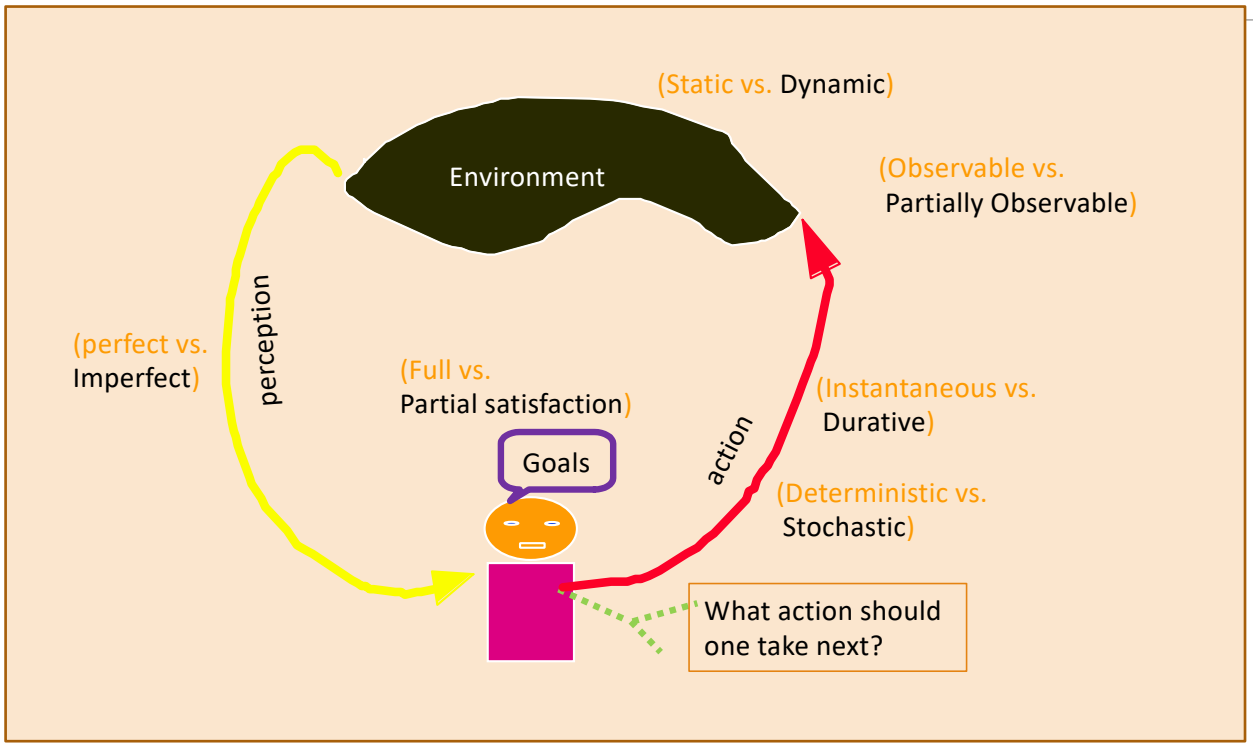
AI => Adaptive/ Intelligent

Software System

- Business Logic Moves to Declarative Data (policy)
- Software is more resilient to changes in environment



Artificial Intelligence (AI) as an Agent



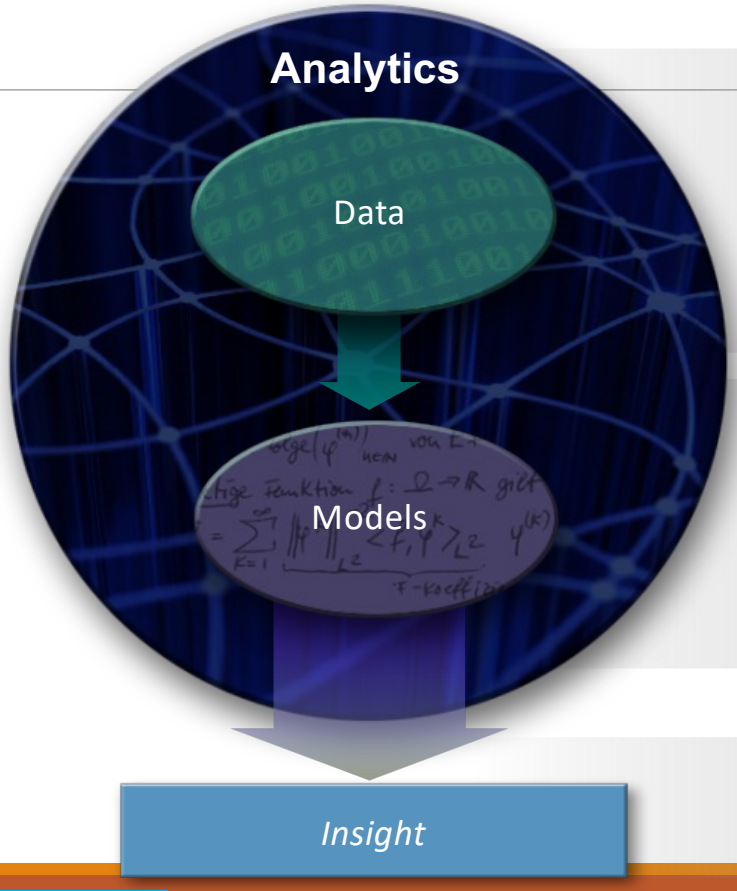
AI deals with perceiving the environment and taking actions towards short- and long term goals as the world changes over time.

From Subbarao Kambhampati's AI Planning Course

Concept: ML and DL

Advanced AI Techniques (Analytics) like Reasoning & Machine Learning

make use of data and models to provide insight to guide decisions

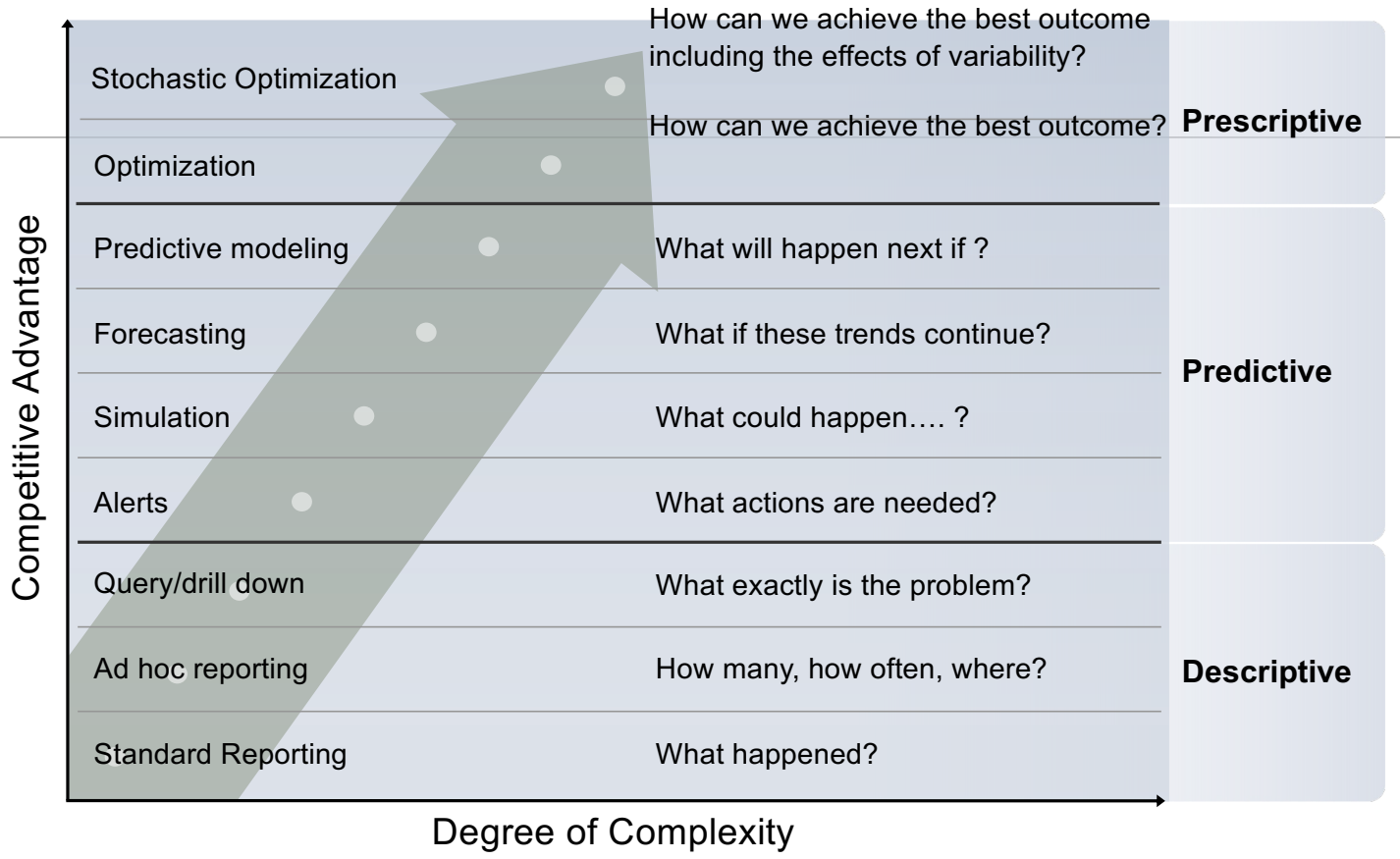


Data sources:
Business automation
Instrumentation
Sensors
Web 2.0
Expert knowledge
"real world physics"

Model:
a mathematical or algorithmic representation of reality intended to explain or predict some aspect of it

Decision executed automatically or by people

Analytics Landscape



Based on: Competing on Analytics, Davenport and Harris, 2007

Example: Adv Prog Course (CSCE 240)

Are they useful? (Descriptive)

- Answering needs an assessment about the past courses

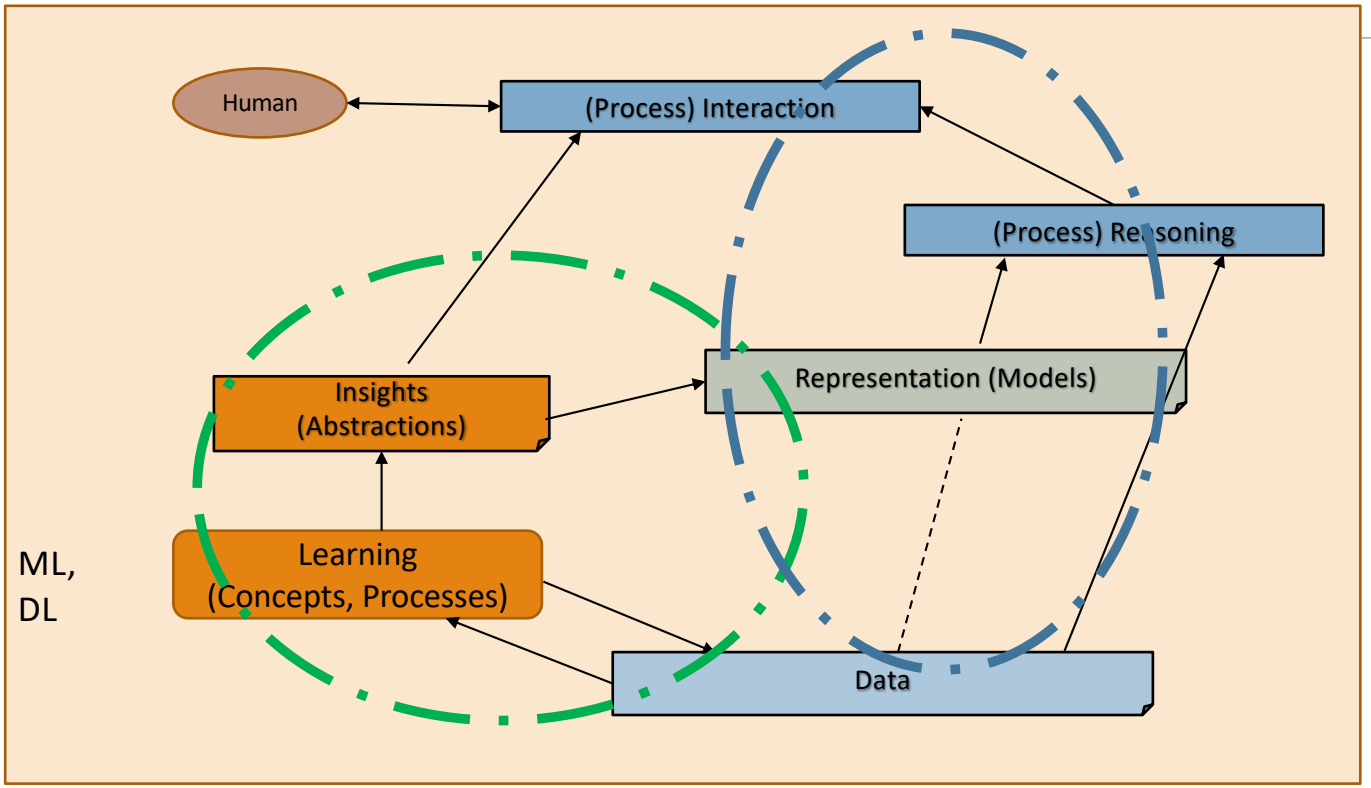
If it happens next time, how many will attend? (Predictive)

- Above + Answering needs an assessment about unknowns (e.g., future of prog. language)

Should you attend? (Prescriptive)

- Above + Answering needs understanding the goals and current status of the individual

Slew of AI Methods



AI: Symbolic, ML, DL

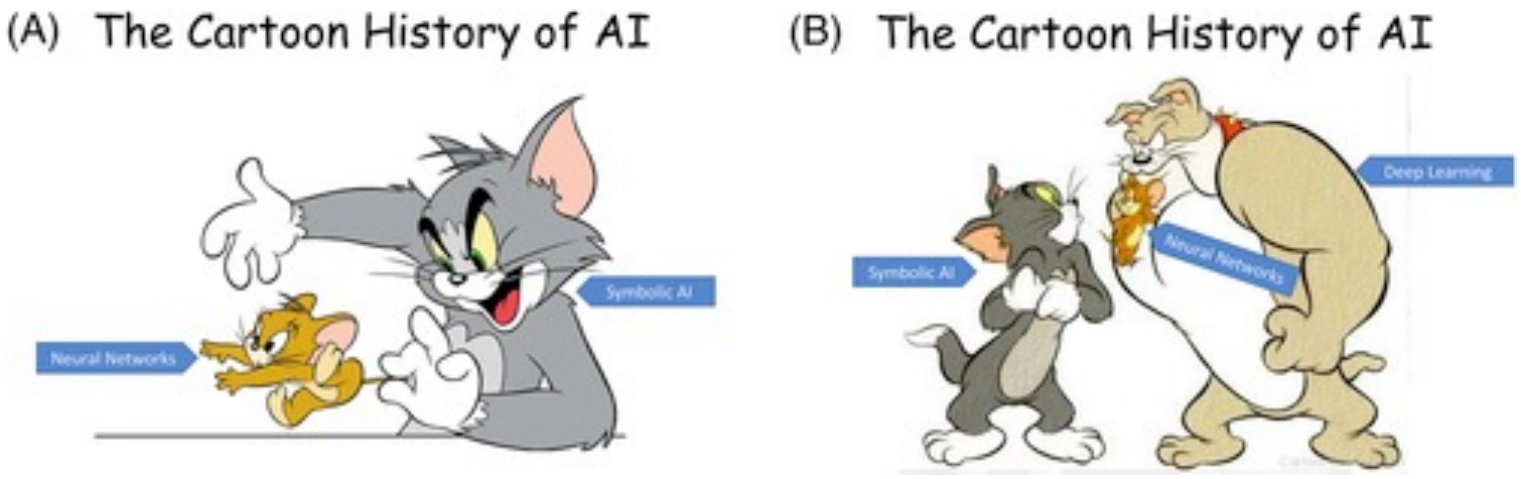


Image credit: https://onlinelibrary.wiley.com/doi/full/10.1002/aaai.12036

Perspective: Successful AI, AI for Society

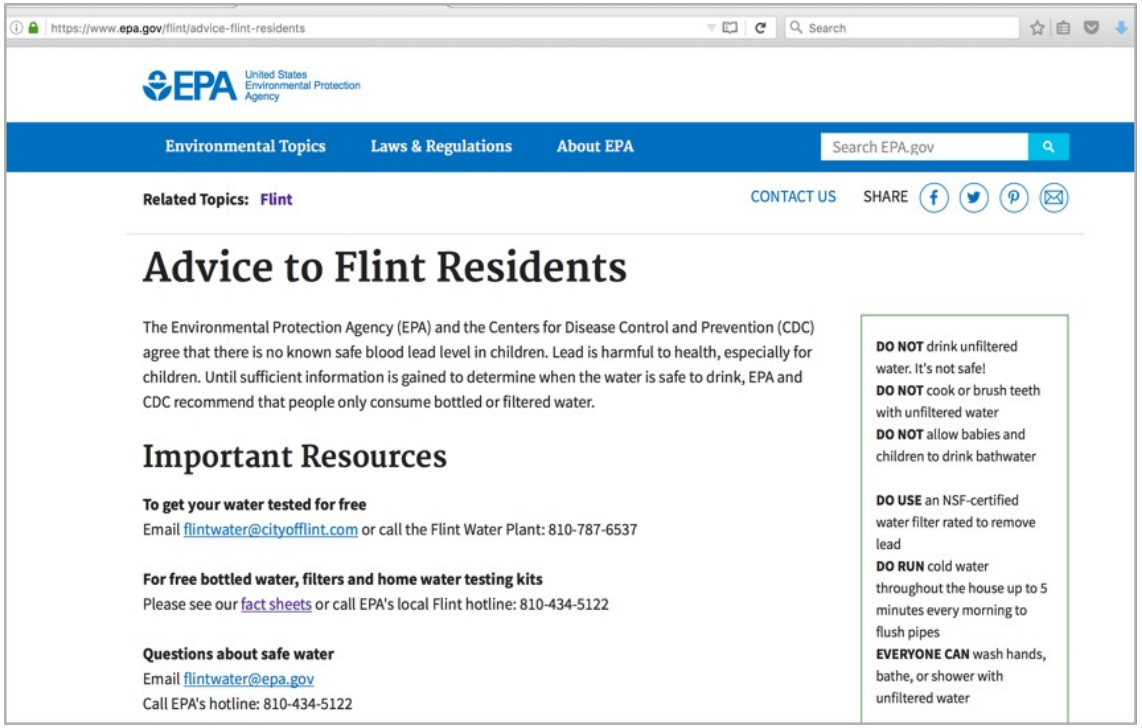
Before and After: Decision Support

Today's tools: Static, non-interactive, non-contextual, lack explanations

Future tools: Dynamic to data, interactive, contextual, explaining with data, anywhere, multi-modal, social (group dependency), societally relevant, …

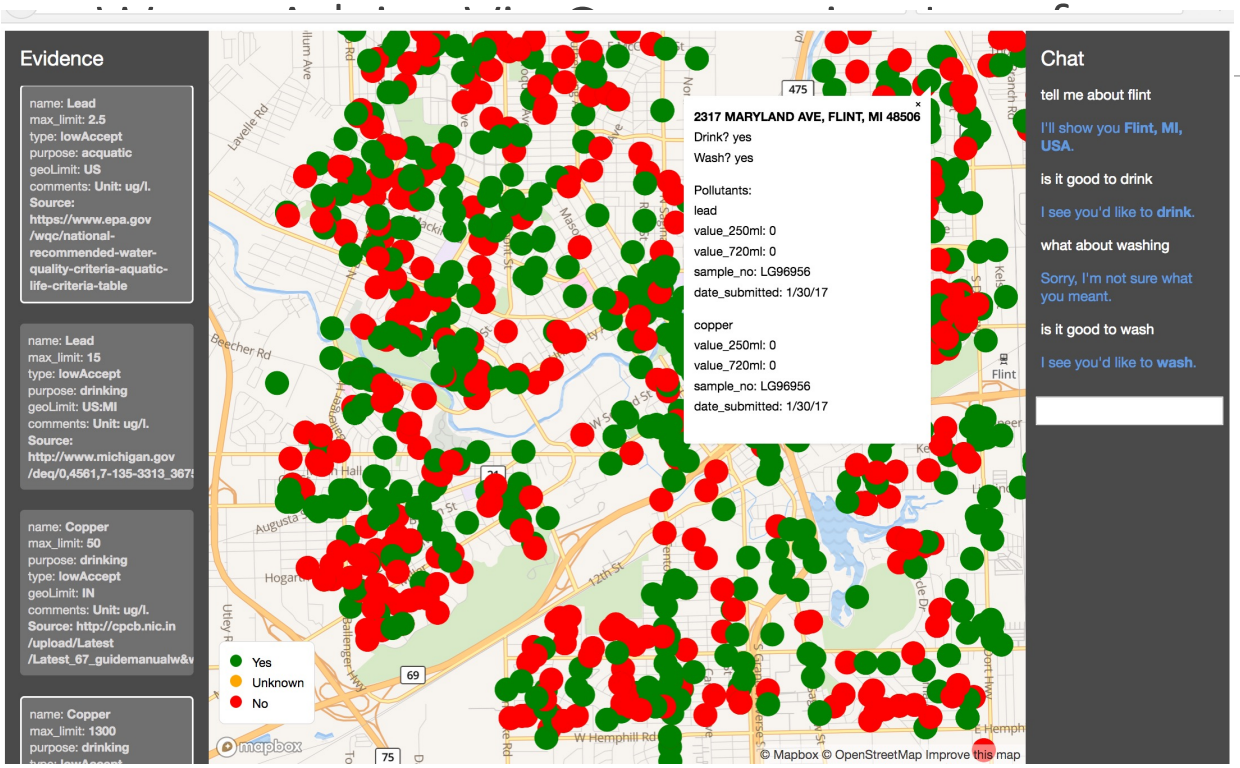
Future has potential to improve people's lives, promote well-being and reduce waste

Water Information to People: Static and Post-Facto Advisories (US)



Advisories to public for Flint Residents, MI, USA

Physical signage at a lake in Washington, USA



Video: https://www.youtube.com/watch?v=z4x44sxC3zA

Paper: Jason Ellis, Biplav Srivastava, Rachel Bellamy and Andy Aaron, Water Advisor - A Data-Driven, Multi-Modal, Contextual Assistant to Help with Water Usage Decisions, AAAI 2018. [Demonstration paper].

AI-Based Decision-Support for COVID-19

- Understanding the disease
  - Disease spread and simulation models
  - Insights by visualization
- Tackling the disease
  - Tracking people's movement
  - Fever detection via images
  - Understanding mental depression from social posts
  - Fighting fake news
- Understanding impact
  - Economic – job loss, industrial growth
  - Supply Chain
  - Risks

- Individual actions
  - *Screening/ triage tools*
- Group actions
  - *Models for how to open economy*
  - *Contact tracing*
  - *Matching producers and consumers: food, medical supplies*
- Policy actions
  - *Understanding impact of policy choices (e.g. lockdowns, travel restrictions)*
  - *Design of economic interventions*

Resource: https://github.com/biplav-s/covid19-info/wiki/AI-and-COVID-19

Concept: AI in Software Development (Testing Focus)

AI for Code Generation

Co-Pilot: https://copilot.github.com/

"GitHub Copilot is an AI pair programmer that helps you write code faster and with less work. GitHub Copilot draws context from comments and code, and suggests individual lines and whole functions instantly. GitHub Copilot is powered by OpenAI Codex, a new AI system created by OpenAI. The GitHub Copilot technical preview is available as an extension for Visual Studio Code, Neovim, and the JetBrains suite of IDEs."

AI *for* Testing

- AI for testing
  - Test case and data generation
  - “Value” based testing
- Sample of work
  - **Blogs**: https://www.perfecto.io/blog/ai-in-software-testing ; https://www.testingxperts.com/blog/AI-in-Software-Testing
  - **Papers**: Artificial Intelligence in Software Test Automation: A Systematic Literature Review, Anna Trudova, Michal Dolezel, Alena Buchalcevová, Published in ENASE 2020, https://www.semanticscholar.org/paper/Artificial-Intelligence-in-Software-Test-A-Review-Trudova-Dolezel/ccbe24b348194905edeca78477625500786e55d6;
    T. M. King, J. Arbon, D. Santiago, D. Adamo, W. Chin and R. Shanmugam, "AI for Testing Today and Tomorrow: Industry Perspectives," *2019 IEEE International Conference On Artificial Intelligence Testing (AITest)*, 2019, pp. 81-88, doi: 10.1109/AITest.2019.000-3.

Testing *for* AI

- Papers
  - A. Aggarwal, S. Shaikh, S. Hans, S. Haldar, R. Ananthanarayanan and D. Saha, "Testing Framework for Black-box AI Models," *2021 IEEE/ACM 43rd International Conference on Software Engineering: Companion Proceedings (ICSE-Companion)*, 2021, pp. 81-84, doi: 10.1109/ICSE-Companion52605.2021.00041. **Video**: https://youtu.be/984UCU17YZI
  - Machine Learning Testing: Survey, Landscapes and Horizons, Jie M. Zhang, Mark Harman, Lei Ma, Yang Liu, https://arxiv.org/abs/1906.10742, 2019
  - Software Engineering for AI-Based Systems: A Survey, Silverio Martínez-Fernández, Justus Bogner, Xavier Franch, Marc Oriol, Julien Siebert, Adam Trendowicz, Anna Maria Vollmer, Stefan Wagner, https://arxiv.org/abs/2105.01984, 2021

What is AI Being Tested For?

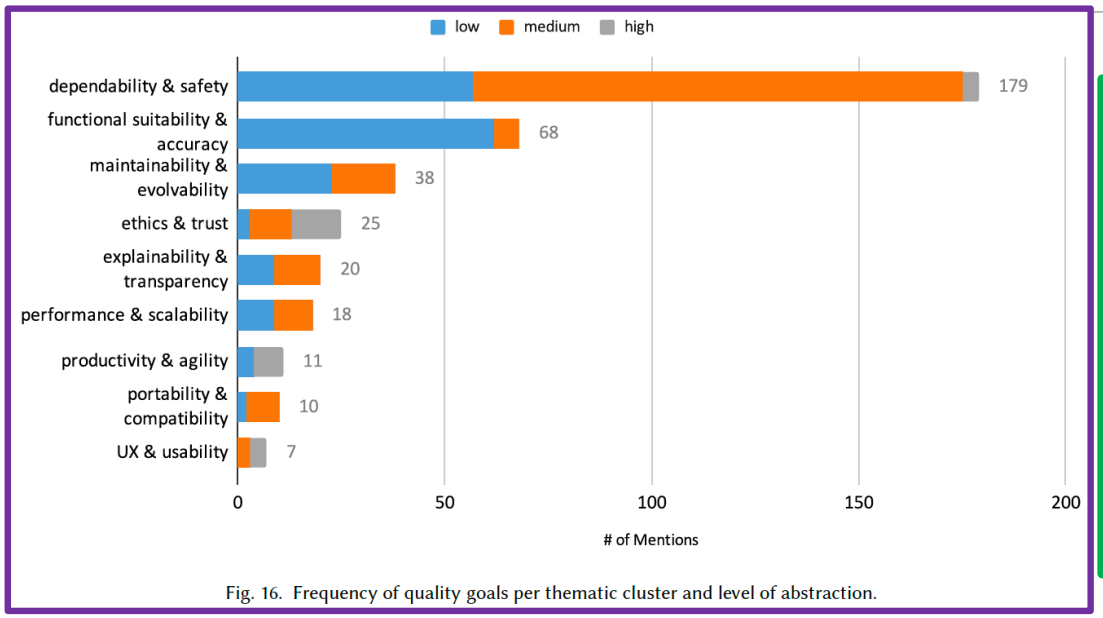


Fig. 16. Frequency of quality goals per thematic cluster and level of abstraction.

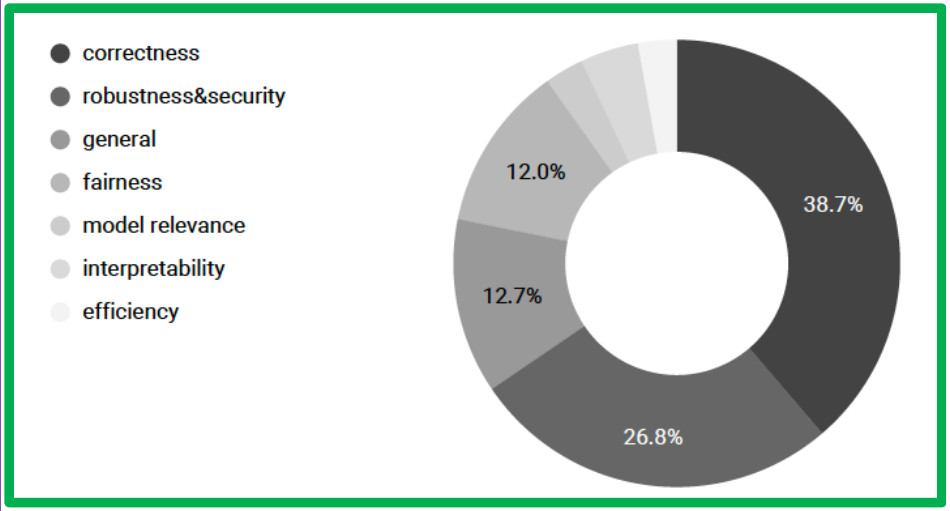


Figure Source: Software Engineering for AI-Based Systems: A Survey, Silverio Martínez-Fernández, Justus Bogner, Xavier Franch, Marc Oriol, Julien Siebert, Adam Trendowicz, Anna Maria Vollmer, Stefan Wagner, https://arxiv.org/abs/2105.01984, 2021

Figure Source: Machine Learning Testing: Survey, Landscapes and Horizons, Jie M. Zhang, Mark Harman, Lei Ma, Yang Liu, https://arxiv.org/abs/1906.10742, 2019

Concept: Problems with AI

An Unstable Collaboration

Human over AI

- Common AI tools for image, speech and text tools (translators)
- Vehicles: Cruise control, Park Assist

AI over Human

- Self parking of car*
- Automated trading*
- Cognitive biases in human decision making**

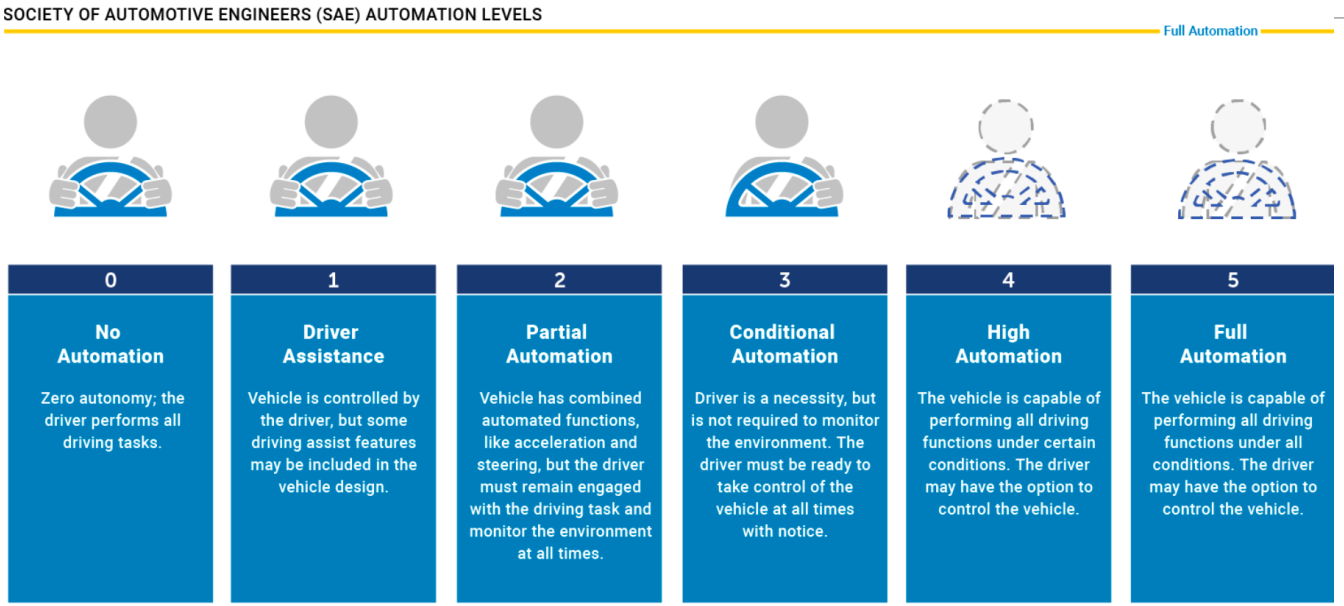
Objection: *When have humans liked control over them?*

Human and AI as equal collaborators is ambiguous

What does this mean in a practical sense ? No clear answer.

- ***Human AI Collectives**, By N. R. Jennings, L. Moreau, D. Nicholson, S. Ramchurn, S. Roberts, T. Rodden, A. Rogers, Communications of the ACM, December 2014, Vol. 57 No. 12, Pages 80-88, 10.1145/2629559, https://cacm.acm.org/magazines/2014/12/180791-human-agent-collectives/fulltext
- ** **Thinking, Fast and Slow** by Daniel Kahneman, https://en.wikipedia.org/wiki/Thinking,_Fast_and_Slow

Misleading Levels of Automation for Vehicles



Sources:

- SAE: https://www.nhtsa.gov/technology-innovation/automated-vehicles
- * Consumer Report: https://www.consumerreports.org/autonomous-driving/levels-of-car-automation/

Questions:

- What is the problem being solved?
- Are humans ready to take over?

Recall the case when humans were not ready to take over?
***Hint**: A flying vehicle with professional drivers!*

- Are you the **driver**, or are you a **passenger** in a self-driving car?*

Fear:

- Getting away with incompetence?
- Getting away with murder!

Instability of AI is Well Recorded

[Text] Su Lin Blodgett, Solon Barocas, Hal Daumé III, Hanna Wallach, Language (Technology) is Power: A Critical Survey of "Bias" in NLP, Arxiv - https://arxiv.org/abs/2005.14050, 2020 [NLP Bias]

[Image] Vegard Antun, Francesco Renna, Clarice Poon, Ben Adcock, and Anders C. Hansen, On instabilities of deep learning in image reconstruction and the potential costs of AI, https://doi.org/10.1073/pnas.1907377117, PNAS, 2020

[Audio] Allison Koenecke, Andrew Nam, Emily Lake, Joe Nudell, Minnie Quartey, Zion Mengesha, Connor Toups, John R. Rickford, Dan Jurafsky, and Sharad Goel, Racial disparities in automated speech recognition, PNAS April 7, 2020 117 (14) 7684-7689, https://doi.org/10.1073/pnas.1915768117, March 23, 2020

References for AI

Textbook

- AI – A Modern Approach (AIMA), S. Russell & P. Norvig, http://aima.cs.berkeley.edu/

Tools and demos

- Code sample in AIMA book
- Learning tools and model libraries
  - https://ai.google/tools/
  - Watson library: https://www.ibm.com/watson/products-services/
  - Exciting startups: https://www.prowler.io/
  - Interchange standards: https://onnx.ai/

Articles and Papers

- New York Time, AI Special Issues, *https://www.nytimes.com/spotlight/artificial-intelligence*, *April 2020*
- McKinsey, Notes from the AI Frontier modeling the impact of AI on the world economy, https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-modeling-the-impact-of-ai-on-the-world-economy, 2018
- Henry A. Kautz, The third AI summer: AAAI Robert S. Engelmore Memorial, 2022, https://onlinelibrary.wiley.com/doi/full/10.1002/aaai.12036
- Biplav Srivastava, Understanding AI and Cognitive Systems – a Perspective on Its Potential and Challenges While Putting Them to Work with People, AI & Cognitive Systems, Issue 4, Vol 2- Issue 1, 2018.

Home Work 6 (Optional)

Due Thursday, April 11, 2023

Home Work (#6) – C++ - Understand Code Optimization

- Consider BubbleSort algorithm for sorting (shown on right)
- Processing
  1. Generate n random numbers – called S
  2. (Store and Sort as Array)
     1. Store the numbers of S in an array: allocated with size n at the start
     2. Sort using Bubble Sort
  3. (Store and Sort as Vector)
     1. Store the numbers of S in a vector: allocated with size 1 and size increased one by one number until n
     2. Sort using Bubble Sort
  4. Measure time difference in both cases with n = 100, 1,000, 10,000, 100,000
- Output
  1. Make a graph showing any difference in timing
  2. Check the sorted results and confirm they are same

Algo 3 (BubbleSort):

- current_array = a = Input
- For (i=0; i<**N-1**; i++) {
  - For (**j=(i+1)**; j<N; j++) {
    - If(a[i] > a[j])
      - Swap(a[i], a[j])
  - }
- }
- **Return current_array**

Home Work (#6) – C++ - Requirement

- So, write a program named: ***SortRandomN***
- It will support inputs/ arguments in the format:
  - n: number // numbers to sort
- Output:
  - Time for array // computed value
  - Time for vector // computed value
  - Result_checked (Boolean) = True/ False // compare the results in both cases

Measure time difference in both cases with n = 100, 1,000, 10,000

Algo 1 (SortRandomN):

- current_array = a = Input
- While (true)
  // Or any limit you want to set
  - Check if current_array is sorted (i.e., a[i-1] <= a[i], for i=1 to N).
  - If yes,
    - **Return current_array**
    - current_array = Permute (current_array) (i.e., swap values of any i, j, i not equal j, for i,j =1 to (N-1))
  - If no, and optional limit exceeded
    - // return fail

Example invocation

> ***SortRandomN*** 1000
Time for array: 1 sec
Time for vector: 2 sec
Result_checked: True

Discussion: Course Project

Course Project – Building and Assembling of Prog. Assignments in Health

- **Project**: Develop collaborative assistants (chatbots) that offer useful information about diseases
- Specifically, use the CDC dataset on diseases at: https://wwwnc.cdc.gov/travel/diseases
  - For polio, it is: https://wwwnc.cdc.gov/travel/diseases/poliomyelitis
  - Each student will choose two diseases (from 47 available).
  - Each student will also use data about the disease from WebMD. Example for polio - https://www.webmd.com/children/what-is-polio
  - Programming assignment programs will: (1) extract data about a disease from two sites, (2) process it, (3) make content available in a command-line interface, (4) handle any user query and (5) report on interaction statistics.

- *Other sources for disease information are possible. Example – NIH https://www.ninds.nih.gov/health-information/disorders*

Core Programs Needed for Project

- Prog 1: extract data from the district **[prog1-extractor]**
- Prog 2: process it (extracted data) based on questions **[prog2processor]**
- Prog 3: make content available in a command-line interface **[prog3-ui]**
- Prog 4: handle any user query **[prog4-userintent2querymapper]**
- Prog 5: report statistics on interaction of a session, across sessions **[prog5-sessionlogger]**

Objective in Programming Assignment # 5:
Record what happens in a chat session and provide summary

- A user may interact with your chatbot for one question or twenty. How did your chatbot do?
- **Record chat your system makes with each user and report on user session as well total usage statistics (since the chatbot was created)**

Approach Suggested

- Under data folder,
  - have a sub-folder called **chat_sessions**
    - When a person starts a chat session (i.e., starts your program and until does not quit), create a file with the " <data>_<time>.txt" as the name. Save the user's utterance and the system's reply there in the order they come. Close this file when the user session ends.
    - Calculate statistics: # user_utterance, #system_utterance and time duration of session
  - have a file called **chat_statistics.csv**.
    - Have a header with columns: S.No, chat_file, # user_utterance, #system_utterance and time taken
    - For each chat file in chat_sessions, there will be a row with the chat statistics you have calculated

Objective in Programming Assignment # 5:
Record what happens in a chat session and provide summary

Approach Suggested

- Under data folder,
  - have a sub-folder called **chat_sessions**
    - When a person starts a chat session (i.e., starts your program and until does not quit), create a file with the " <data>_<time>.txt" as the name. Save the user's utterance and the system's reply there in the order they come. Close this file when the user session ends.
    - Calculate statistics: # user_utterance, #system_utterance and time duration of session
  - have a file called **chat_statistics.csv**.
    - Have a header with columns: S.No, chat_file, # user_utterance, #system_utterance and time taken
    - For each chat file in chat_sessions, there will be a row with the chat statistics you have calculated

- Goal: report statistics on interaction of a session, across sessions [Name: **prog5-sessionlogger**]
- One can invoke it with arguments
  - **prog5-sessionlogger –summary**
    - **There are 12 chats to date with user asking 23 times and system respond 24 times. Total duration is 456 seconds.**
  - **prog5-sessionlogger –showchat-summary 2**
    - **Chat 2 has user asking 2 times and system respond 2 times. Total duration is 4 seconds.**
  - **prog5-sessionlogger –showchat 2**
    - **Chat 2 chat is:**

      …
  - **prog5-sessionlogger –showchat 200**
    - **ERROR: there are only 12 chat sessions. Please choose a valid number.**

Programming Assignment # 5

- Code organization
  - Create a folder in your GitHub called "**prog5-sessionlogger**"
  - Have sub-folders: src (or code), data, doc, test
  - Have data directory as shown in previous slide
    - ./data/**chat_sessions/**
    - ./data/ **chat_statistics.csv**
  - Write a 1-page report in ./doc sub-folder
  - Put a log of system interacting in ./test
  - Send a confirmation that code is done by updating Google sheet; optionally, send email to instructor and TA

- Use concepts learned in class
  - Exceptions
  - File operations
  - Dynamic memory

Core Programs Needed for Project

- Prog 1: extract data from the district **[prog1-extractor]**
- Prog 2: process it (extracted data) based on questions **[prog2processor]**
- Prog 3: make content available in a command-line interface **[prog3-ui]**
- Prog 4: handle any user query **[prog4-userintent2querymapper]**
- Prog 5: report statistics on interaction of a session, across sessions **[prog5-sessionlogger]**

Prog 6: Assembling the Chatbot

- Have a program - **[myrep-chatbot]**
- User interacts with the chatbot with any utterance and the system has to answer – see right
- User can ask about statistics and query log
  - Same as PA5
  - See next slide

[#1] "Quit" or "quit" or just "q" => Program exits

[#2a]"Tell me about the disease", "Tell me about the rep" => Disease Information (Type-I1)
… (Type-I2)

[#2l]"Tell me everything" => Give all information Extracted (Type-I12)

[#3] "What diseases do you support for Q/A" => Give list of diseases

[#4] "Give me your usage stats" => Give chat summary info

[#5] *<User can enter any other text and the program has to handle it>* => "I do not know this information" or
"Here is my guess - " + <query> + <answer>. "Did I answer correctly ? "

All Queries to be Supported

[#1] "Quit" or "quit" or just "q" => Program exits

[#2a]"Tell me about the disease", "Tell me about the rep" => Disease Information (Type-I1)
… (Type-I2)

[#2l]"Tell me everything" => Give all information Extracted (Type-I12)

[#3] "What diseases do you support for Q/A" => Give list of diseases

[#4] **"Give me your usage stats" => Give chat summary info**

[#5] *<User can enter any other text and the program has to handle it>* => "I do not know this information" or
"Here is my guess - " + <query> + <answer>. "Did I answer correctly ? "

Chatbot usable in debug mode

myrep-chatbot –summary
=> There are 12 chats to date with user asking 23 times and system respond 24 times. Total duration is 456 seconds.
- **myrep-chatbot** –showchat-summary 2=> Chat 2 has user asking 2 times and system respond 2 times. Total duration is 4 seconds.
- **myrep-chatbot** –showchat 2

=> Chat 2 chat is:
…
- **myrep-chatbot** –showchat 200

=> ERROR: there are only 12 chat sessions. Please choose a valid number.

Project – PA#6

- Code organization
  - Create a folder in your GitHub called "**myrep-chatbot**"
  - Have sub-folders: src (or code), data, doc, test
  - Have data directory as shown in previous slide
    - ./data/**chat_sessions/**
    - ./data/ **chat_statistics.csv**
  - Write a
    - Report in ./doc sub-folder. Credit reuse
    - Create a presentation in ./doc sub-folder
  - Put a log of system interacting in ./test
  - Send a confirmation that code is done by updating Google sheet; optionally, send email to instructor and TA

- Use concepts learned in class
  - Exceptions
  - File operations
  - PA1 to PA5 from yourself or others; credit reuse in Readme, report and presentation

<Student Name> - Project Summary

	Criteria	Information	What Needs to Change to Support Additional Diseases (Reuse Situation)
1	Disease and data (CDC, WebMD) information		
2	How data is extracted and merged		
3	How extracted data is stored		
4	How intent is detected		
5	How answer is given/ shown		
6	How statistics is calculated		

Class Diagram

Due Next Class

Concluding Section

Lecture 24: Concluding Comments

- Programming practice for project assignments based on PA#4
- We discussed
  - Templates
  - Class templates
  - Functional templates
- HW 6 – due on Tuesday (Aug 11)
- Project –
  - Summary due on Tuesday (Aug 11)
  - Full project due on Tuesday (Aug 18)

About Next Lecture – Lecture 25

Lecture 25: Review for Quiz 2

- Review of concepts
- Project summary due – PA1 to PA6

20	Mar 23 (Th)	Advanced: Operator overloading	Prog 4 – end (March 26, 2023)
21	Mar 28 (Tu)	Advanced: Memory Management	Prog 5 – start
22	Mar 30 (Th)	Advanced: Code efficiency	
23	Apr 4 (Tu)	Advanced: Templates	
24	Apr 6 (Th)	AI / ML and Programming	Prog 5 – end
25	Apr 11 (Tu)	Review material for Quiz 2 PA1-5 summary by each student	HW 6 due Prog 6 – assembling start
26	Apr 13 (Th)	In class test	Quiz 2 – In class
27	Apr 18 (Tu)	Project presentation	Prog 6 - due