



HAZOP Automation/Augmentation with AI

Agenda

- History of AI and how it works
 - Expert systems
 - Fuzzy logic
 - Neural networks
 - Generative Pretrained Transformer (GPT)
- PHA and implementation challenges
- Areas where AI automate/augment the PHA process
 - Process safety information development
 - Discussion recording and summarization (and translation)
 - Generate information to assist (replace?) the team performing the study



What is this?

How do you know?

Answer:

Because it looks like cat

What did you NOT do...

- Taxonomy of Cats
 - Kingdom- Animalia
 - Phylum- Chordata – *dorsally situated central nervous system*
 - Subphylum- Vertebrata
 - Class- Mammalia
 - Order- Carnivora
 - Family- Felidae
 - Genus- Felis
 - Species- Catus

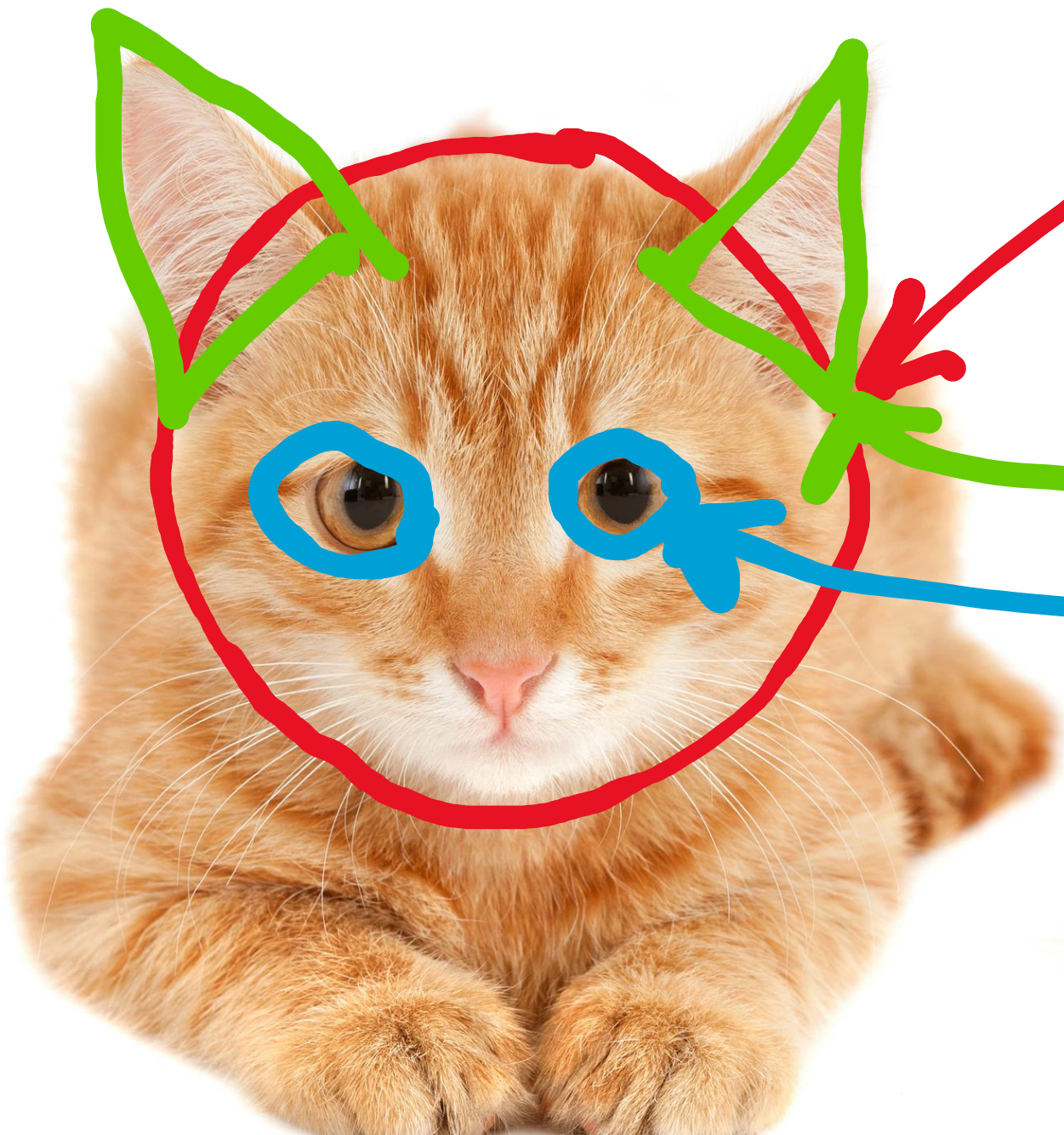


Expert System

- Earliest attempt at artificial intelligence
- First-order logic
 - Sequence of if-then statements (rules)
 - Results in selection of solution from collection of options
- Represents how humans think that they think...
- Problems
 - Well defined input data and potential outputs required
 - “Brittle” – easy to make the system fail
- Example: Diagnose disease based on symptoms



You also did not ...



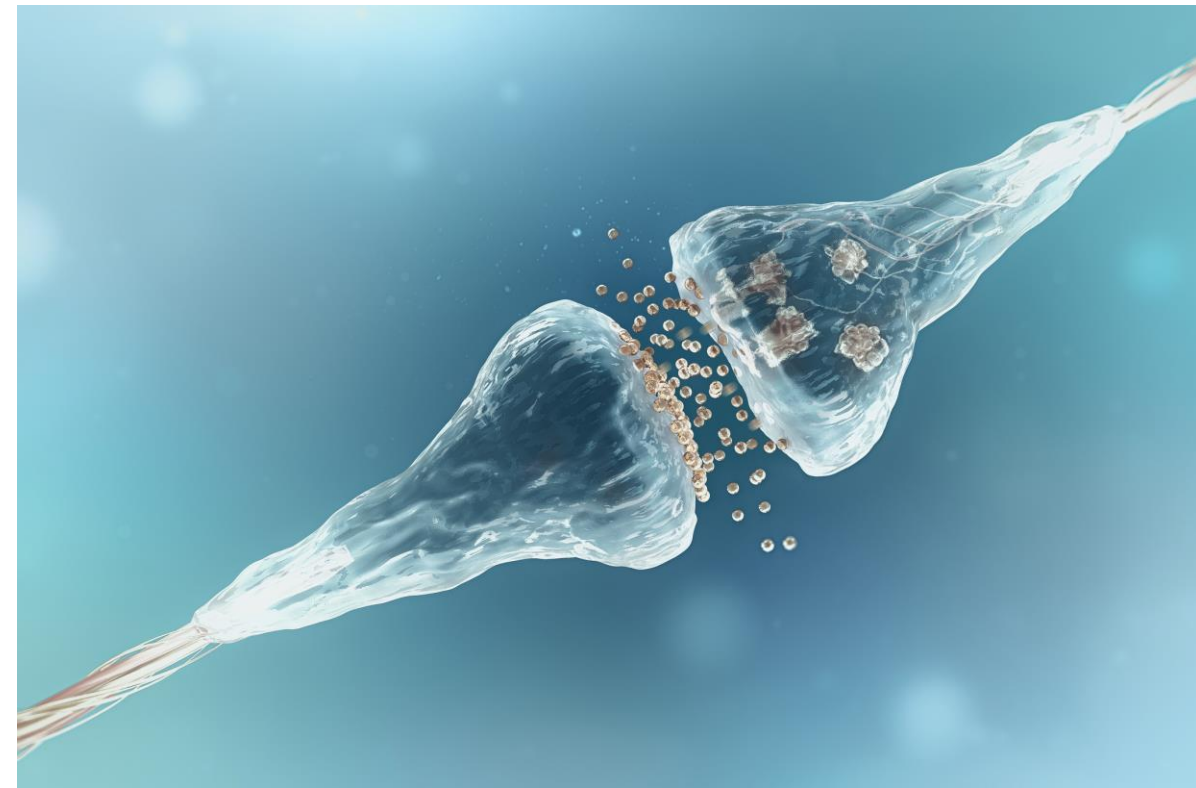
Round thing on top

Triangle shape x2 on circle

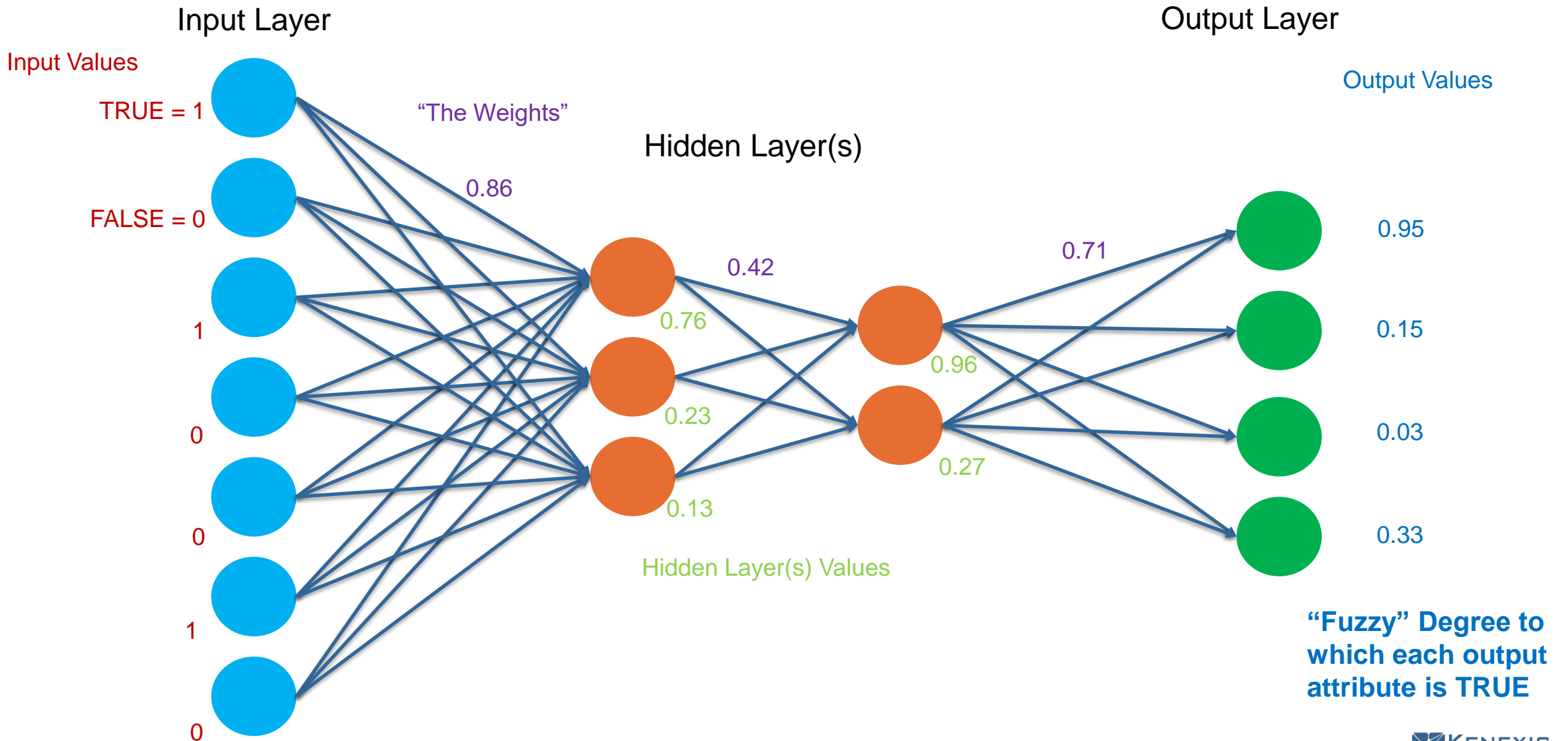
Two smaller circles in the big circle

The human nervous system

- Neurons transmit stimuli to memory locations to trigger response
- As stimuli patterns are repeated the pathways are reinforced
- Patterns of stimuli generate a response in memory (recognition)
- Speed imperative



Artificial Neural Network



Fuzzy Logic

- Much of human “pattern recognition” is not strictly TRUE or FALSE
- Replace TRUE/FALSE with “Degree of Membership in the Set”
 - 0 – Not a member of the set
 - 1 – “Archetype” of the set
 - Between 0 and 1 – Member of the set, to a degree
- NOT A PROBABILITY OF TRUTH!!!!



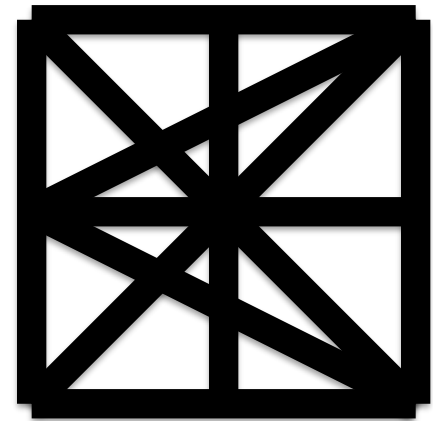
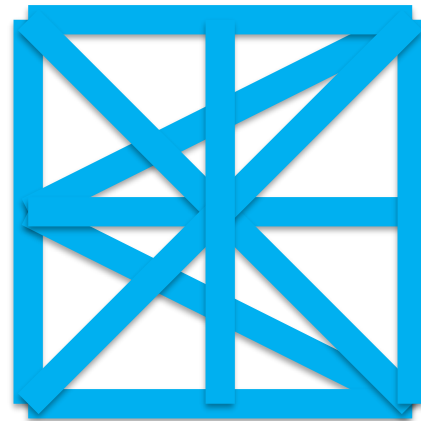
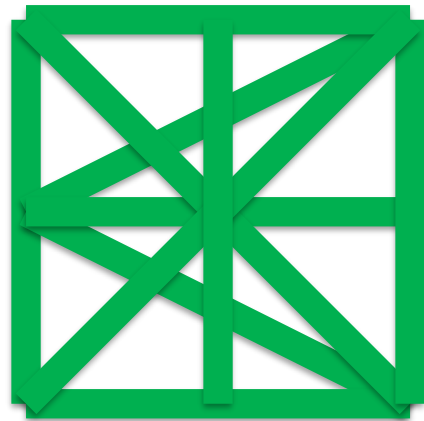
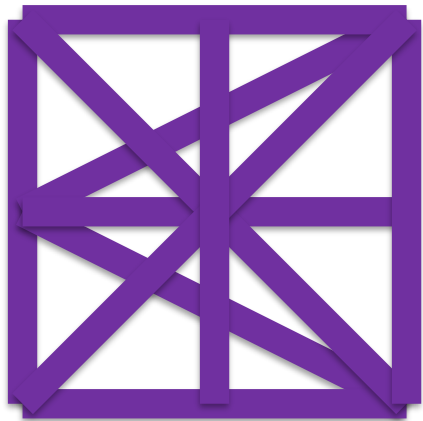
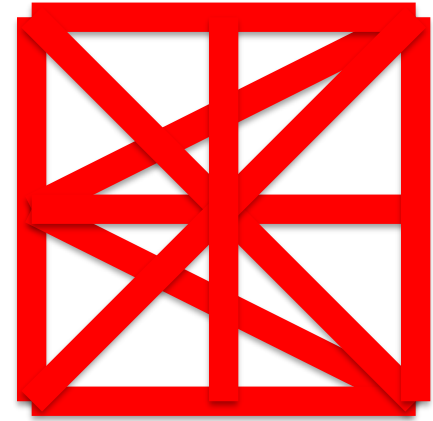
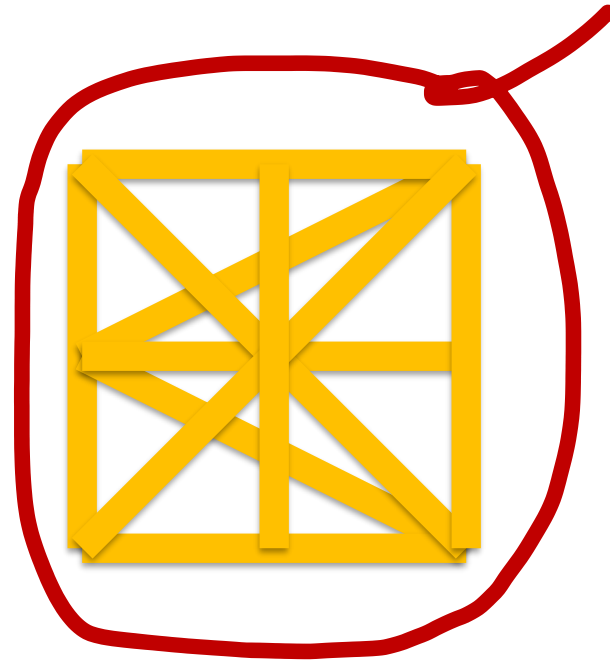
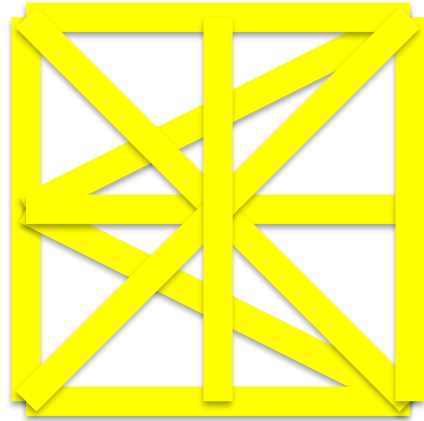
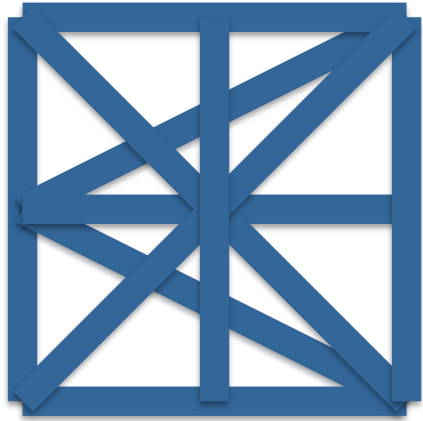
ar·che·type

/ˈärk(ə), tīp/

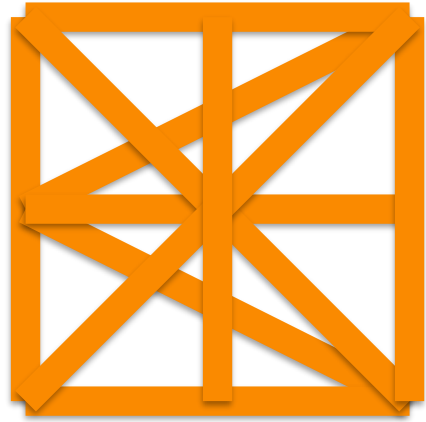
noun

a very typical example of a certain person or thing.
"the book is a perfect archetype of the genre"

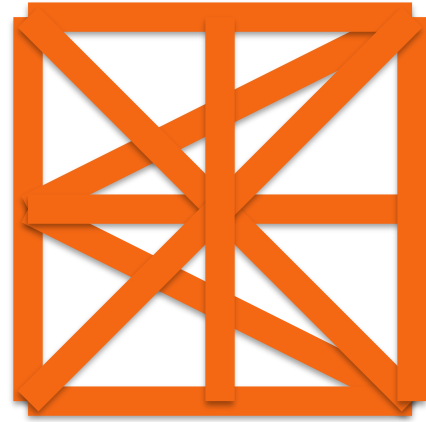
Which of these is orange?



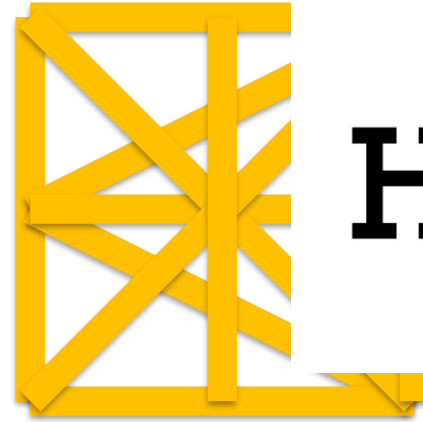
Which of these is orange?!?!?



RGB = < 250 , 138 , 0 >



RGB = < 244 , 104 , 20 >



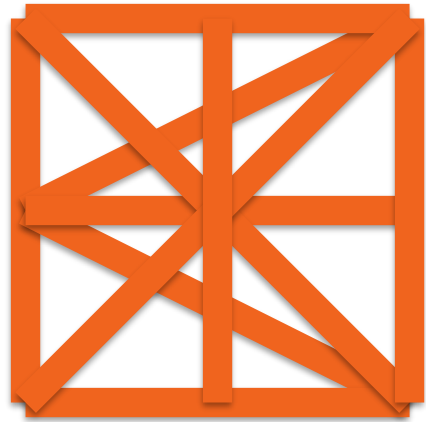
RGB = < 255 , 192 , 0 >



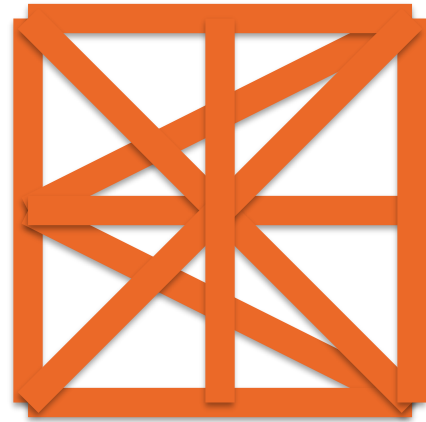
HERMÈS
PARIS



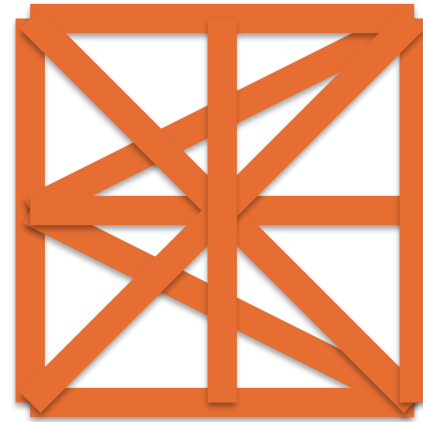
RGB = < 231 , 165 , 46 >



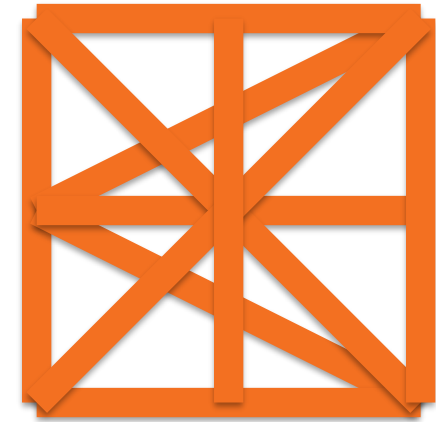
RGB = < 240 , 100 , 30 >



RGB = < 235 , 105 , 40 >



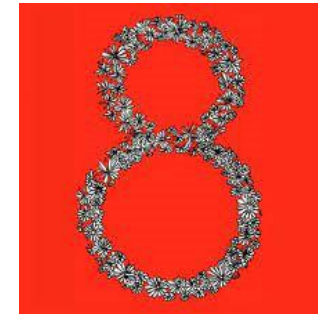
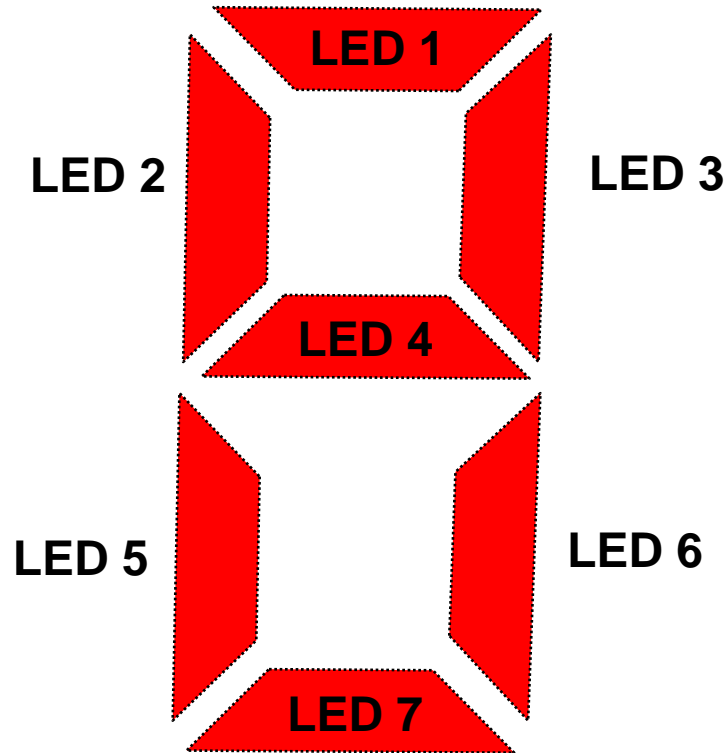
RGB = < 230 , 110 , 50 >



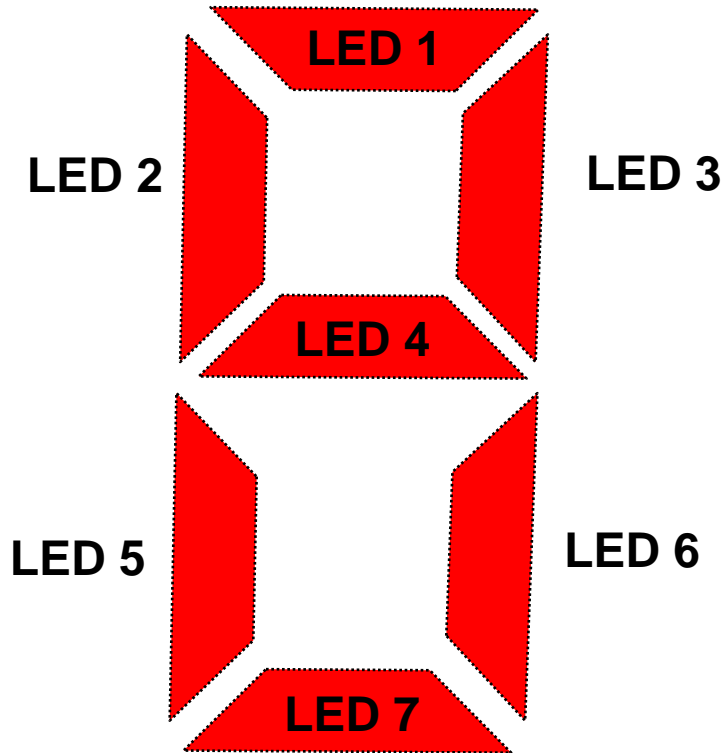
RGB = < 243 , 112 , 33 >

They're all different colors!!!

What number is this? How do you know?



Expert System Classification



If LED1 = TRUE and
If LED2 = TRUE and
If LED3 = TRUE and
If LED4 = TRUE and
If LED5 = TRUE and
If LED6 = TRUE and
If LED7 = TRUE
Then
Number = 8



ANN LED Number Classifier

Input Values

TRUE = 1

FALSE = 0

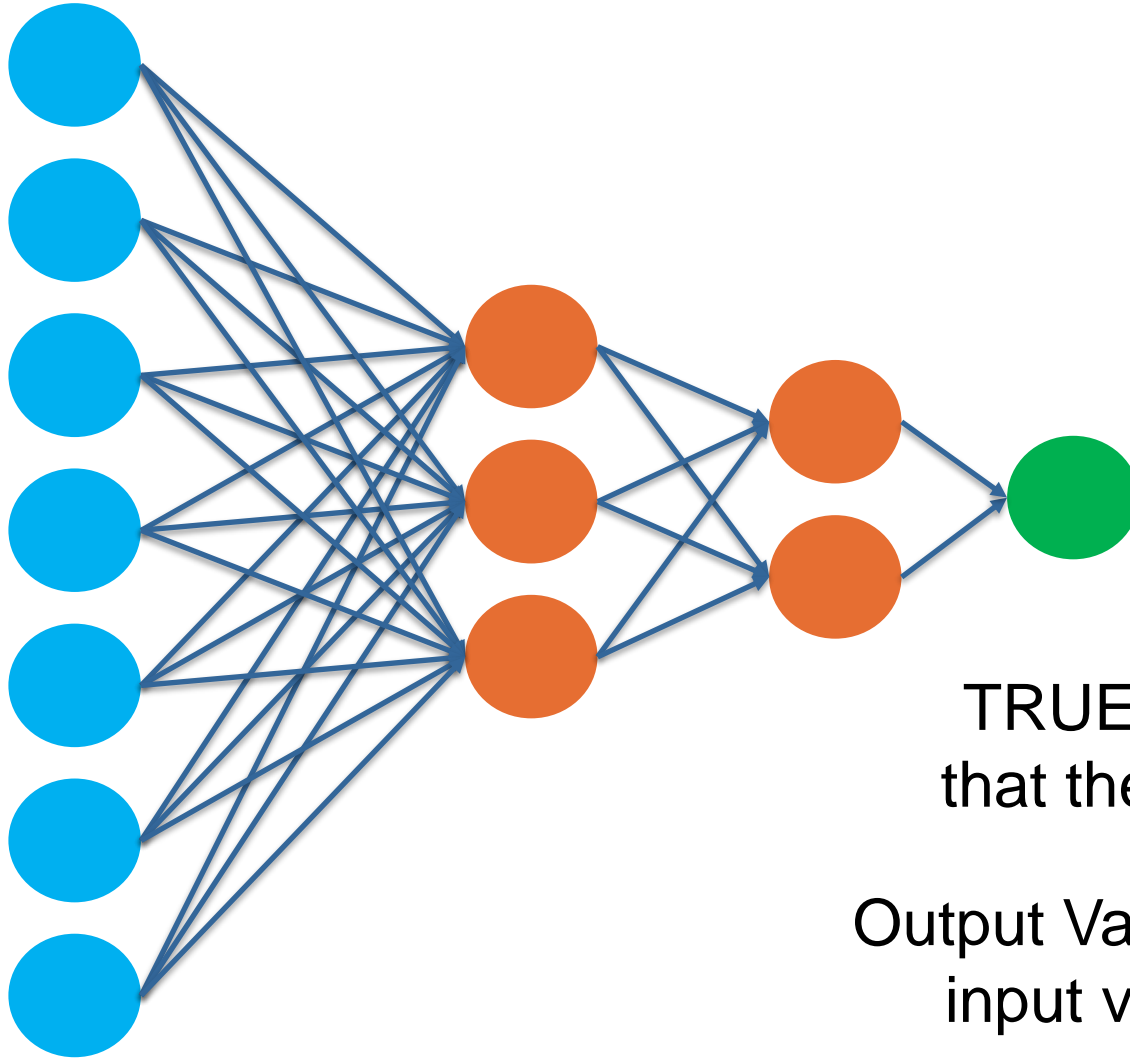
1

0

0

1

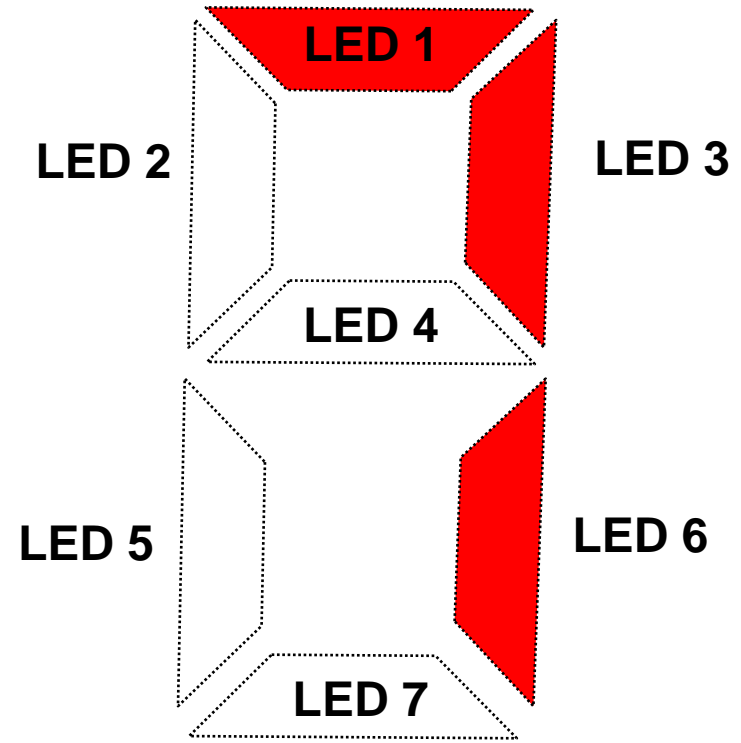
0



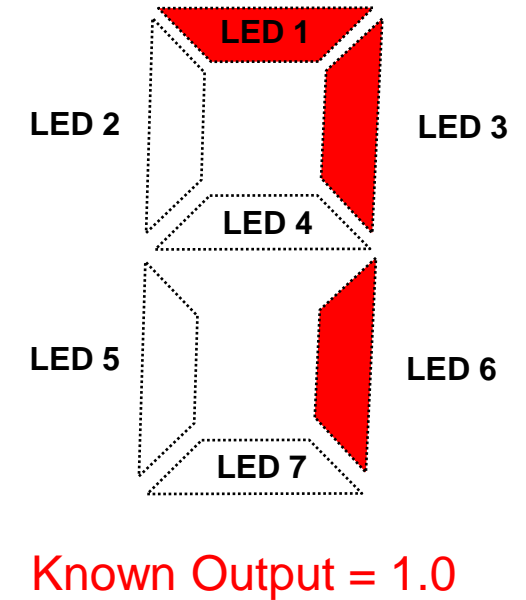
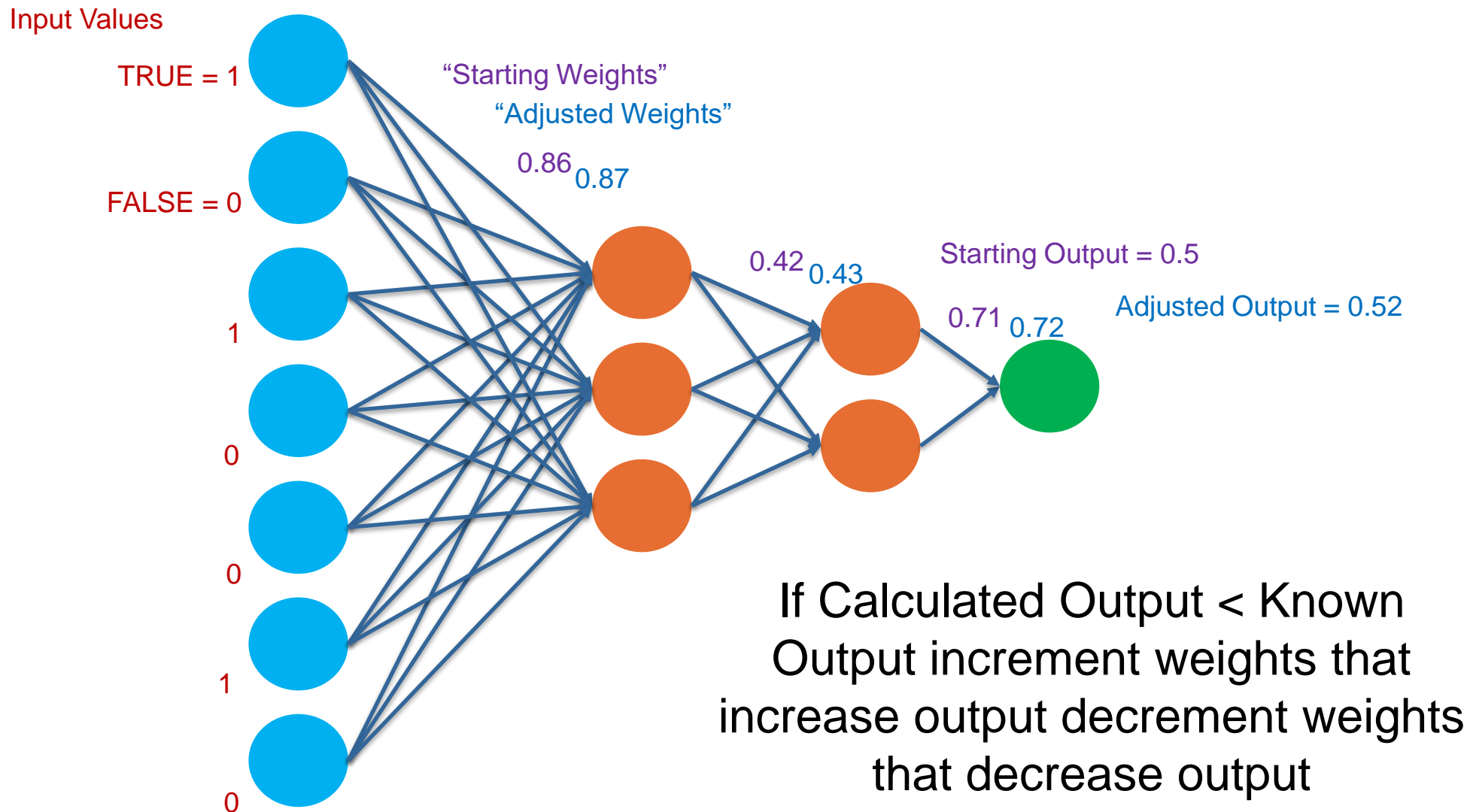
Output = 0.95

TRUE (e.g., > 0.7)
that the number is 7

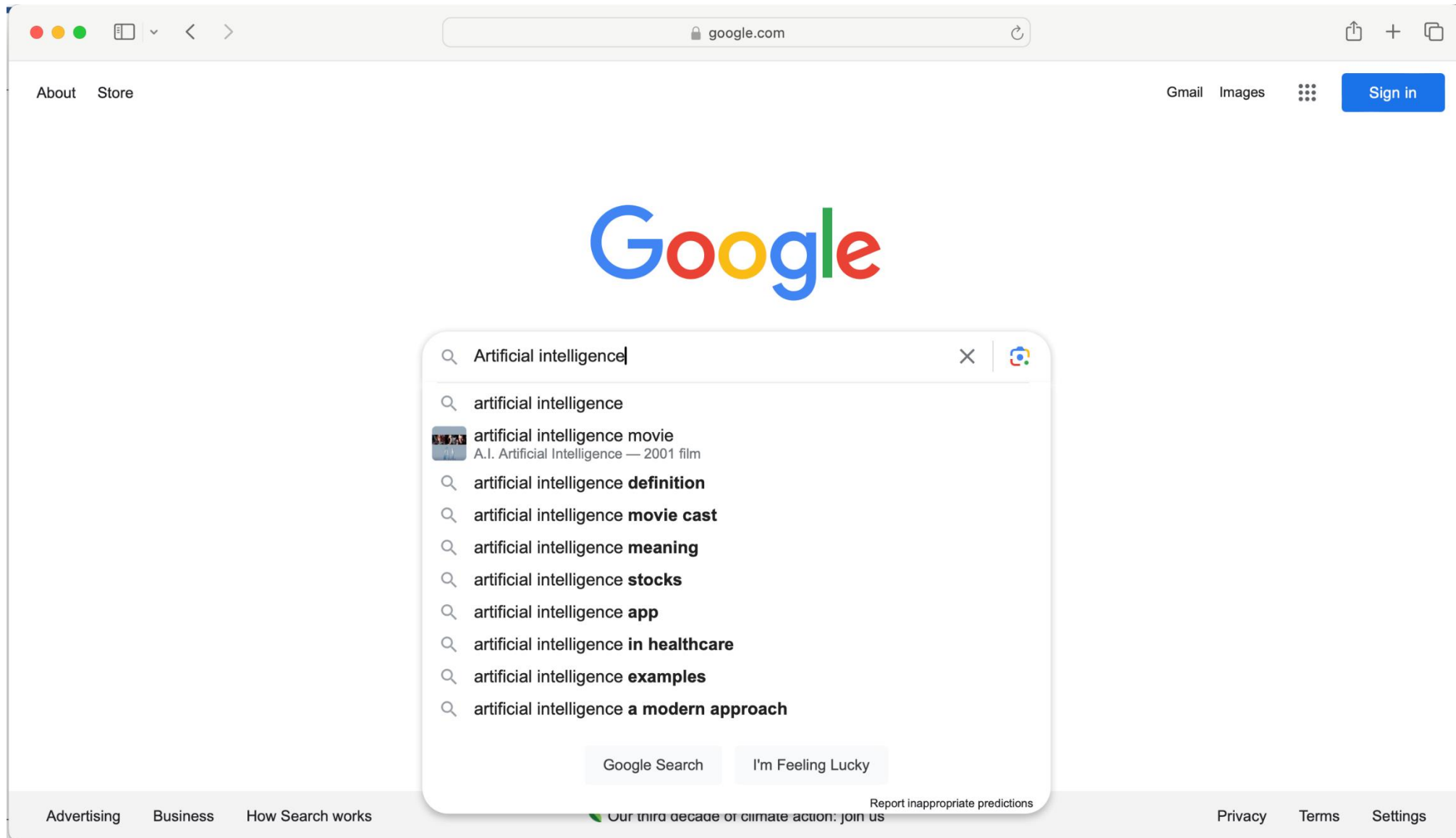
Output Value is calculated from
input values and weights



Where do the weights come from? Training...



Toward Large Language Models - Autofill



The image shows a screenshot of the Google homepage in a web browser. The browser's address bar shows "google.com". The page features the Google logo in the center. Below the logo is a search bar containing the text "Artificial intelligence". A dropdown menu of search suggestions is visible below the search bar, listing various related terms and phrases. At the bottom of the page, there are links for "Advertising", "Business", "How Search works", "Privacy", "Terms", and "Settings".

Search suggestions for "Artificial intelligence":

- artificial intelligence
- artificial intelligence movie
A.I. Artificial Intelligence — 2001 film
- artificial intelligence **definition**
- artificial intelligence **movie cast**
- artificial intelligence **meaning**
- artificial intelligence **stocks**
- artificial intelligence **app**
- artificial intelligence **in healthcare**
- artificial intelligence **examples**
- artificial intelligence **a modern approach**

Buttons: Google Search, I'm Feeling Lucky

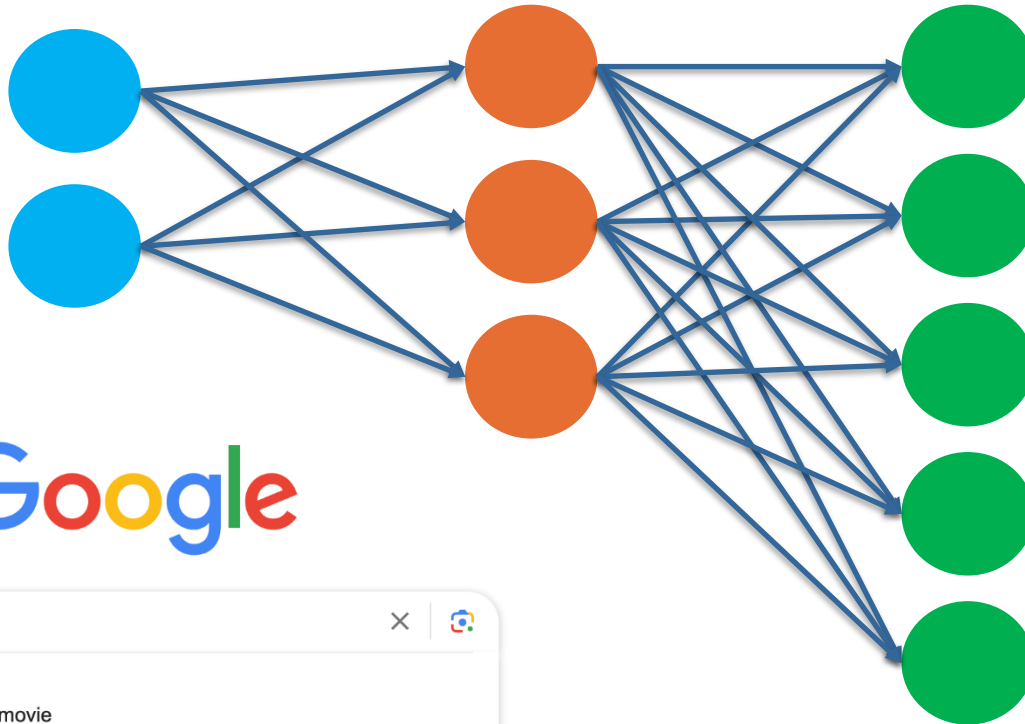
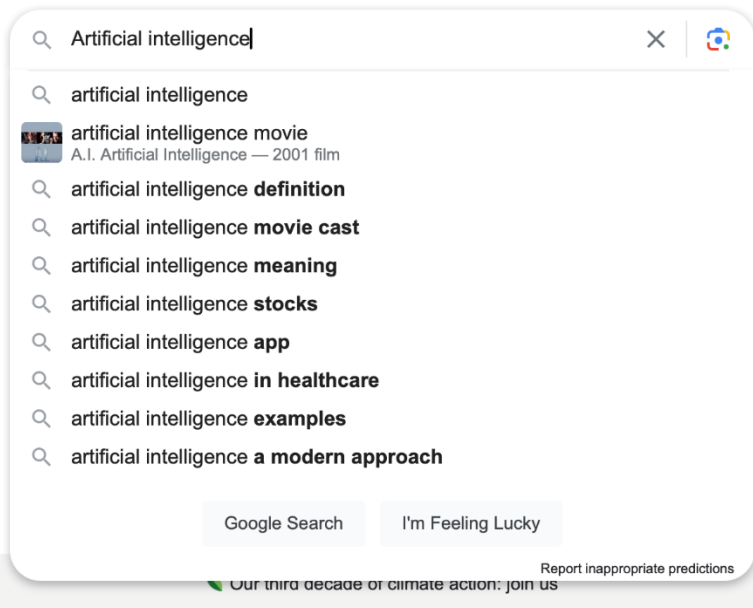
Footer: Advertising, Business, How Search works, Privacy, Terms, Settings

ANN Autofill Predictor

Input Values

“Artificial”

“Intelligence”



Output Values

“Movie” = 0.95

“Stocks” = 0.91

“Examples” = 0.87

“In Healthcare” = 0.89

“Definition” = 0.93

LLM Terminology

- Token – a piece of text the model processes a single unit
 - Single words
 - Collection of words
 - Pre-fixes
 - Individual letters (not commonly used)
- Chunking – Extract phrases (tokens) from unstructured text, group on syntax
 - “The quick brown fox” (Noun token)
 - “jumps over” (Verb Token)
 - “the lazy dog” (Noun token)



You

what does the quick brown fox jump over?



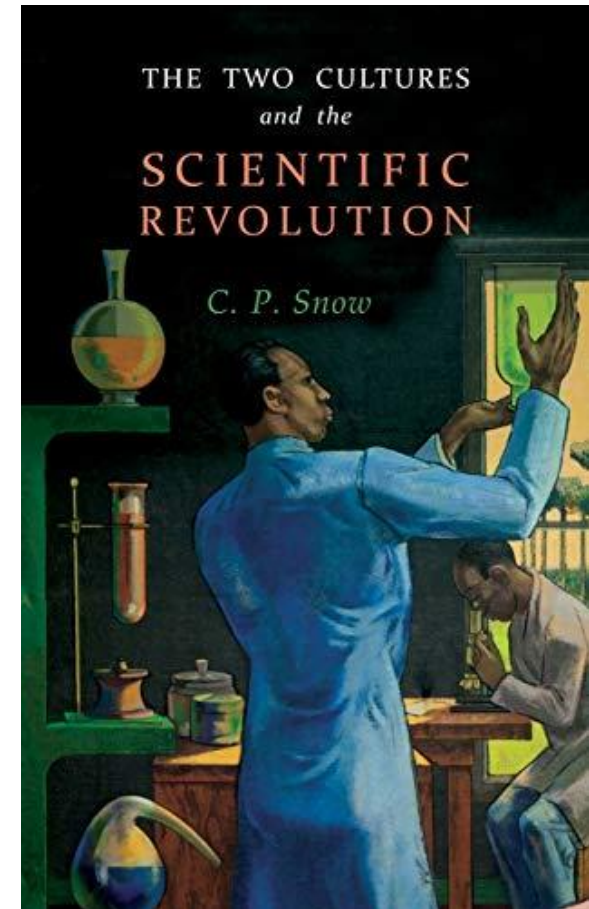
ChatGPT

The quick brown fox jumps over the lazy dog.



LLM Training

- Text sources are targeted (text, PDF, web posts, Facebook entries)
- Text is chunked into tokens and classified
- Noun tokens are inputs
- Verb Tokens are outputs
- Weights are adjusted with assumption that If noun tokens are inputs then verb tokens are TRUE
- Artificial intelligences are ***Literary Artists*** not ***Applied Scientists***
- ***“Plagiarism Mash-Up”***



Potential Pitfalls of LLM

- Who decides what is in the training set?
- Are models trained on proprietary information and trade secrets?
- Who decides that is TRUE?




- Do the models include copyrighted information?
 - Am I at risk of “tortious interference” of a copyright agreement if I use information from an LLM?

Applying AI Tools to Process Hazards Analysis

- PHA reports have room for improvement
 - Insufficient PHA is routinely identified as a root cause in CSB accident investigations
 - PHA is extremely time-consuming and resource intensive
 - Important scenarios are often overlooked
 - Risk is often under-estimated because consequences are not sufficiently elaborated
 - Expert experienced team members are not available, knowledge is missing
- AI tools can help to address shortcomings

Automate Preparation and PSI Incorporation

9 Jun 09	 3366 Riverside Drive, Suite 200, Columbus OH 43221		
23 Jun 09			
DRAWING TITLE			
High Pressure Separator Gas Production Facility			
g Courses\Sample Process for			
DRAWING NUMBER		SHEET	REV
D-254-002		2 OF 6	1

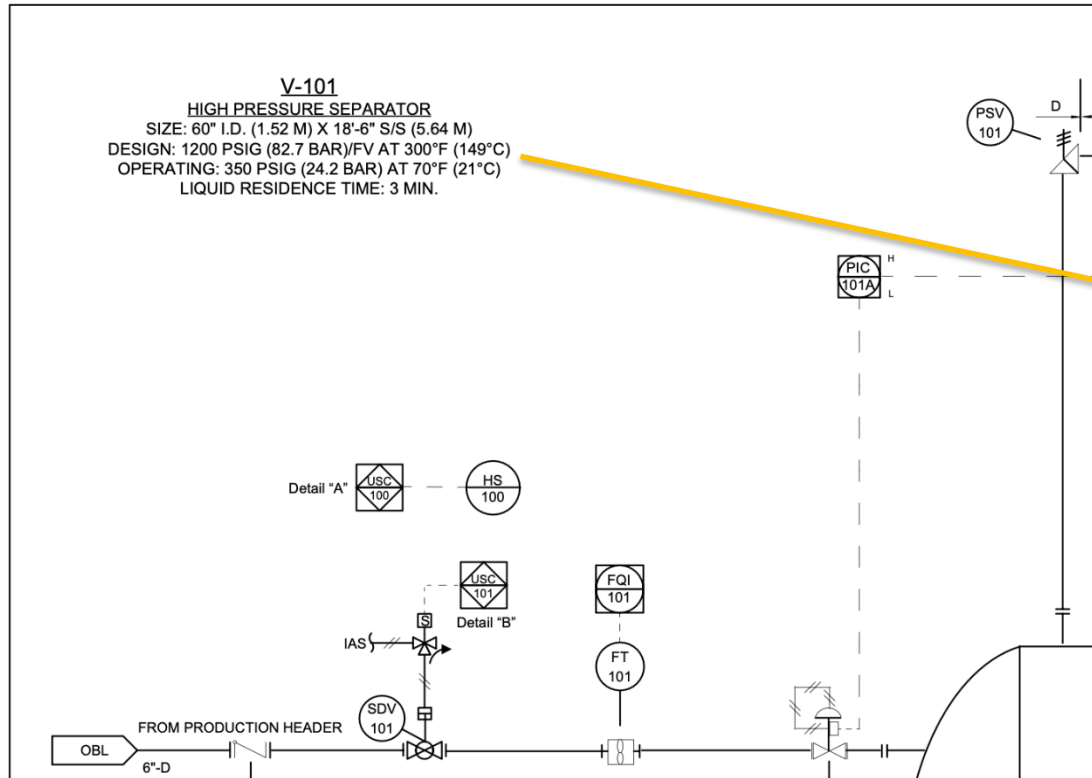
KENEXIS OPEN PHA Texas City Gas Plant HAZOP

Study Data Nodes Deviations PHA Worksheets LOPA Worksheets Check Lists

Parking Lot Risk Criteria Premium Tools Back

Documents

Drawing	Revision	Document Type	Description
D-254-001	1	PFD	Gas Production Facility
D-254-002 Sh. 1 of 6	1	P&ID	Legend Sheet - Gas Production Facility
D-254-002 Sh. 2 of 6	1	P&ID	High Pressure Separator - Gas Production Facility



KENEXIS OPEN PHA Texas City Gas Plant HAZOP

Signed in as Edward Marszal of Kenexis

Study Data Nodes Deviations PHA Worksheets LOPA Worksheets Check Lists

Recommendations Safeguards Parking Lot Risk Criteria Premium Tools Back

Nodes

Description	Intention	Design Conditions	Operating Conditions
1 (HP Gas) Production Header through High Pressure Separator (V-101) to Gas Export Pipeline	Entry of high pressure gases into the process from the wellheads and production manifold, and transfer of low pressure gas for delivery to the sales gas export pipeline.	MAWP = 1200 psig @ 300 F	700 psig @ 70 F (From production header) 350 psig @ 40 F (From HP separator)

Transcribe and Summarize Discussions

- Transcribe meeting discussions by participant
- Automatically generate attendee list / participation /duration
- Facilitated by web conferencing
- Summarize discussions-based prompt
 - For the node of high-pressure separator and the deviation of high level and the cause of outlet valve closed summarize the consequence in 100 words or less
- Insert results into worksheet in appropriate location



Suggest Appropriate Responses – Fully Automate

- Based on context sensitive LLM query – for a gas plant in the low-pressure separator node for the low pressure deviation whose causes is inlet control loop failure where the valve goes to the open position, what are expected safeguards

PHA Worksheets

2. (Liquid Stream) High Pressure Separator (V-101) to Low Pressure Separator (V-102)

Search Worksheet...

Deviation	Consequence	Cause	Safeguards	
			Safeguard	Type
	notes the spacing of the equipment is large enough to reduce flame impingement from one vessel to another vessel.		Operator response to V-102 high pressure alarm.	
			Fire protection and insulation due to vessel support structure.	
2.2 Low Pressure	2.2.1 Potential for vacuum in LP Separator M-102. Potential introduction of air into LP Separator. No safety hazard identified - vessel is	2.2.1.1 Failure of control loop LIC-101 causing LV-101 to fail too closed.	Potential Safeguards: High Level safety instrumented function that closes inlet valve High Level alarm with operator response	
		2.2.1.2 Inadvertent closure of SDV-		

Potential Pitfalls – Required Improvement

- AI Tools cannot read P&IDs
 - Customization with training on P&ID content
- AI Tools mis-transcribe technical language
 - LLM Customization with training on technical language / names
- LLM does not know my processes
 - LLM Customization with training on process information
- LLM does what safeguards I use
 - LLM Customization with training on prior PHAs
- Customization of LLM for PHA assistance
 - Site / Enterprise / Industry Group

Conclusions

- Decades of research has lead to the current state of AI
- Large language models have been built from an underpinning of fuzzy logic and artificial neural networks
- Large language models have weaknesses that will require customization for process safety purposes
- PHA can benefit from AI by automating tasks and making specific information available in context
- Useful AI for PHA will require significant work in training of LLM



Questions?

