



uOttawa

CSI5101 - Knowledge Representation
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ASSIGNMENT - 1 “Explorations around Knowledge”

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Exploration 2 - Psychology

Q1 – AI and Perception

Smell and Taste are certainly the two senses less developed today within AI agents. What is the company trying to develop? Can you find additional articles/blogs that relate to their development or to similar developments for smell and taste? Discuss those two senses. What do you think about the future developments?

The company is developing a chip (neural processing device) that processes input from all five human senses (auditory, olfactory, gustatory, visual, and somatosensory) directly on the device, rather than uploading this information to a data centre (as is common in most conventional AI solutions). Additionally, the learning and continuous training of the AI models is done in a resource-efficient way directly on the chip. The idea behind the product is "Beneficial AI", wherein the data processed by the different sensors can be used for a variety of human-beneficial purposes, including vehicle navigation, industrial process monitoring, identification of diseases from breath, taste-testing medicines, proper navigation of machines in various physical conditions, and so on, which may use one of the five senses or a combination of multiple senses to achieve the solution.

Additional blogs/articles related to similar developments for smell and taste

Although most AI systems over the past few years have focused on using visual and audio data, there are a few recent AI developments in the smell and taste spaces.

a. Smell

Most research in this area focuses on predicting the odour of chemical compounds based on the analyzed molecular structure, rather than using olfactory data directly. For instance, one study (Lee et al., 2022) presents an "odor map", which uses AI to distinguish between smells by clustering similar smells together. The data that the models use does not include smell directly, but rather the chemical structure of different compounds, and the result of the study was that the model's smell prediction was closer to the expert panel's decision compared to the prediction of the volunteers in the study.

The Brainchip Akida uses sensors to detect compounds and then passes that data to its processors (Vanarse et al., 2022). As such, there are several studies related to using the presence or absence of certain compounds to solve other problems, including diagnosing Parkinson's disease (Casjens et al., 2013) using machine learning methods, which is the same task mentioned in the original article about the Brainchip Akida. Similarly, work has been done on determining the types of odor affected in Alzheimer's disease with random forest models (Velayudhan et al., 2015).

b. Taste

The IBM Hypertaste is an "e-tongue" that recognizes chemical patterns in liquids through an AI-assisted sensor by recording voltages from liquids and then analyzing them either on the device or on the cloud through machine learning algorithms (IBM Research, 2019). The main usage of such a system is in identifying unknown substances, which has a variety of applications in supply chain, manufacturing, scientific research, etc. In terms of identifying the flavours of food, researchers at the Pennsylvania State University have developed an "e-tongue" to identify and differentiate between food flavours using graphene-based electronic sensors to detect certain molecules (Sharma, 2023).

Discussion of those two senses

Smell and taste are incredibly difficult to quantify (in comparison to data from the other senses), which is probably why there has not been much work in using AI to deal with such data. Most AI systems rely on labeled data from humans, but this presents a variety of issues. Firstly, it is a well-accepted fact that taste is subjective. What one person might classify as "spicy" might just be classified as "mild" by another person. Further, certain flavours are perceived differently based on the genetics of the taster. For example, the taste of cilantro/coriander is described as flavourful by most people, except for a significant minority of people who possess the OR6A2 olfactory receptor gene, which causes cilantro to taste soapy to them (Eriksson et al., 2012). In terms of smell, common vocabulary is unable to distinguish between complex smells. For instance, a person might describe multiple smells as "fruity" (which is a very generic term), but would most likely be unable to pinpoint exactly what fruit or what combination of fruits is producing the smell. If humans are bad at describing tastes and smells, it becomes incredibly difficult for them to generate valuable labeled data to train AI agents on. The way the Brainchip Akida deals with this, is to circumvent the subjectivity and instead have sensors for different molecules, and then passing that data to downstream tasks, which appears to be successful based on the original article.

Our opinion about the future developments

The development of AI applications for smell and taste is still in its early stages, but the potential benefits for healthcare, food safety, and diagnostics are significant. Continuous learning capabilities of Akida processors, as mentioned in the original article, suggest a future where AI systems for smell and taste can adapt and improve based on new information, theoretically contributing to enhanced precision and reliability. As technology evolves, the integration of sensory fusion, combining smell and taste with other sensory data processing, could provide more comprehensive and precise information in various applications. Currently, Google Lens is an application that can identify objects directly by pointing a phone camera at them. Perhaps an

analogous product could be developed using taste or smell, or even by combining all the senses together, to perform tasks like identifying unknown substances, preparing food that fits the taste-palette of a particular user, and so on. On the other hand, it does not appear like much research is going into these areas. The majority of recent AI developments have been on text and image data, both of which are part of the visual sense. In our opinion, there needs to be some significant incentive and marketing that drives people towards such research areas. For example, with computer vision, there is the goal of self-driving cars, and with NLP, there are large language models that function as intelligent chatbots. In our opinion, "e-tongue" and "e-nose" are not catchy enough to draw people towards furthering research in these areas. While there are definitely interesting use-cases, we think it will take a few more years before there are mainstream applications of smell-based and taste-based AI agents.

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Q2 – Cognitive Processes

Situation to analyze = *Self-Driving Car*

TO DO: Fill out the table, providing examples of what would be necessary for each process for a self driving car. No need to know to understand the technology, your answer should be about what is NEEDED, not necessarily how it would be done

Self-driving cars, also known as autonomous vehicles or driverless cars, are automobiles equipped with advanced technologies and systems that enable them to navigate and operate without direct human input. These vehicles use a combination of sensors, cameras, radar, lidar, GPS, and algorithms (Synopsys) to perceive their environment, make decisions, and control their movements.

Coming to human cognitive psychology, processes such as perception, memory, learning, thought, attention, and language are achieved through sensory information from the environment through Visual, Auditory, olfactory, touch, and taste cues. Self-driving cars aim to replicate certain aspects of human perception and decision-making. The below table highlights the way the self-driving car emulates the cognitive processes for its decision-making.

Cognitive Process	Example
Perception	<p>Perception is the process of having an internal description of the external environment (Crowley, and Demazeau 1993). Perception is vital for a self-driving car to perceive its environment. Self-driving cars perceive the environment through (Burke 2019),</p> <ol style="list-style-type: none">1) Camera2) Radar sensors - Radar (Radio Detection and Ranging) uses radio waves to detect and locate objects.

	<p>3) Lidar sensors- Lidar (Light Detection and Ranging) uses laser beams to measure distances</p> <p>Figure 2.1: Self-Driving car with different levels of sensing of the environment (ImageSource)</p>
Attention	<p>Attention is the ability to focus on the task. These vehicles observe the environment using high definition sensors, cameras and GPS. In order to make better decisions, self-driving cars collectively use the data from sensors, algorithms and perception to help the car focus on relevant information and dynamically adjust its attention based on changing conditions.</p> <p>Figure 2.2: Tesla detecting real time objects and marking the point of attention such as traffic signals and cars at the side. (ImageSource)</p> <p>This is achieved using different technologies and hardware. Few are mentioned below,</p>

	<p>GPS (Global Positioning System): Provides the vehicle's absolute position on the Earth. GPS systems help in providing information such as Positioning and Localization, Routing and Navigation, Map Matching. These systems provide data to self-driving cars about road networks, traffic regulations, and real time traffic updates that enable the vehicle to focus and make the best decision during autonomous driving.</p> <p>Decision making algorithms/Technology:</p> <p>Just as humans use their attention to make decisions, autonomous vehicles have decision-making algorithms that analyze the perceived environment and choose appropriate actions. A research study indicates (Liu, Qi et al, 2021) details and compares several decision making technologies used in Autonomous vehicles.</p>
Language	<p>Autonomous vehicles use a variety of technologies to communicate with humans both inside and outside the vehicle. Effective communication is crucial for ensuring safety and providing a seamless experience for passengers and other road users. For passengers inside the vehicle communication with the vehicle is possible through simple voice commands or Touchscreens and Gesture Recognition. The importance of language is that the self-driving vehicles should be able to understand the instruction/feedback from the user and make decisions accordingly.</p> <p>Voice Assistant: The majority of these virtual assistants in the automotive industry are created to seamlessly integrate with the vehicle infotainment systems to offer drivers a variety of voice-activated functionalities, including hands-free phone calls, weather updates, music streaming, and voice-activated navigation.</p>
Memory	<p>In the context of autonomous vehicles, the term "memory" refers to the vehicle's ability to store and recall information needed for various functions, such as navigation, decision-making, and learning.</p> <p>Sensor Data Buffer: To store sensor data for analytics</p> <p>Map memory: To store the maps in memory to work even in offline mode</p> <p>An article indicates that the Researchers from Cornell University have developed a way to help autonomous vehicles create “memories” of</p>

	previous experiences and use them in future navigation, especially during adverse weather conditions when the vehicles cannot safely rely on their sensors. HINDSIGHT is an approach that uses neural networks to compute descriptors of objects as the car passes them. It then compresses these descriptions, which the group has dubbed SQuaSH (Spatial-Quantized Sparse History) features, and stores them on a virtual map, like a “memory” stored in a human brain.
Learning	The self-driving cars are continuously learning from the environment from the data it received from its sensors, cameras. Most of the autonomous cars work with AI technologies under the hood which are deep neural networks. The concept of Neuronal AI is to continuously learn when making mistakes and alter weights. This process of backpropagation that happens is the learning that the model/system does in order to better itself at the task.
Thinking process	Thinking process in machines, particularly in the context of autonomous vehicles, involves complex algorithms and decision-making frameworks designed to enable the machine to perceive, interpret, and respond to its environment.

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Q3 – Humor

What do you think of this answer? Do you see any connection with what we discussed in class?

This answer accurately explains the reason the joke is funny. It does this by explaining the background knowledge required to understand it (as discussed during the lecture) and juxtaposing this with the literal meaning of the joke. One more layer of the joke is about how a space bar could also be a play on the word "bar" as in a location where people get alcoholic beverages. This is something that ChatGPT missed out in its response.

Find 2 jokes that you think are interesting on this site [101 Short Jokes Anyone can Remember \(updated May 2023\)](#). For each joke, either (1) explain the background knowledge necessary to understand it (and find it funny or not!), or (2) ask ChatGPT why it's funny and give your opinion of ChatGPT's answer.

Joke 1: "I try not to tell dad jokes ...But when I do, he thinks they're funny."

For this joke, the background knowledge involves knowing what a 'dad joke' is. When the reader knows that a dad joke is a simple, corny joke often using puns or being very literal, then they would recognize that this joke itself is a dad joke. With this knowledge, a reader might find it funny (or perhaps cringe, because dad jokes are often intentionally cringe-worthy).

The following image is ChatGPT's response on why the joke is funny:

You
Explain why this joke is funny:

I try not to tell dad jokes ...

But when I do, he thinks they're funny.
∅

ChatGPT
The humor in this joke arises from a clever play on the term "dad jokes" and a double entendre involving the phrase "he thinks they're funny."

"Dad jokes" are a category of humor characterized by being cheesy, pun-based, or intentionally corny. The joke sets up the expectation that the speaker is making an effort to avoid telling these types of jokes, perhaps because they are aware of the stereotypical nature of dad jokes and want to steer clear of them.

However, the punchline reveals a twist when the speaker says, "But when I do, he thinks they're funny." Here, "he" refers to the dad. The humor lies in the fact that, despite the speaker's attempt to avoid telling dad jokes, the dad finds them amusing. It's a play on the idea that dad jokes are often considered cheesy or groan-worthy, and the dad's appreciation for them despite the speaker's attempt to avoid them adds an amusing twist to the joke.

ChatGPT's answer successfully captures the aspects that make this joke funny with explanations of the background knowledge surrounding dad jokes. However, it misses out on the fact that this joke itself is a dad joke.

Joke 2:

"I tried to sue the airport for misplacing my luggage.

I lost my case."

The background knowledge for this joke involves knowing that one's luggage is often deposited at an airport and that passengers do not have access to their checked in luggage until after the flight, knowing that a passenger does not always receive their luggage back due to the airport accidentally misplacing it, knowing that this is something one can sue an airport for, and knowing that the word 'case' refers to both a suitcase as in luggage as well as legal action to be decided in a court.

The following image is ChatGPT's response on why the joke is funny:

You

Explain why this joke is funny:

I tried to sue the airport for misplacing my luggage.

I lost my case.

ChatGPT

This joke is a play on words and has a clever double meaning. The humor comes from the dual interpretation of the phrase "I lost my case."

On one hand, "I tried to sue the airport for misplacing my luggage" sets up the expectation that the person is taking legal action against the airport for losing their luggage. However, the punchline reveals a different interpretation of "lost my case." Instead of winning the legal case against the airport, the joke playfully suggests that the person lost their physical suitcase or luggage ("case").

The humor lies in the clever wordplay, as "losing the case" can be understood both in the legal sense of not winning the lawsuit and in the literal sense of misplacing the suitcase. The unexpected twist creates a humorous moment, making it a witty and entertaining joke.



The response perfectly encapsulates the elements that make the joke funny. In our opinion, it does not miss any important aspects, but does skip out on explaining the background knowledge required, which to be fair, was not specifically requested for in our query.

Q4 – Bloom's taxonomy

The [blooms taxonomy](#) is a hierarchical model used for classification of learning objectives into levels of complexity and specificity. The different levels of the pyramid are remember, understand, apply, analyze, evaluate and create. The Generative AI models such as GPT is trained on loads of data and is capable of generating new content from the learning it acquired during model training. This section will analyse how GenAI say for example [ChatGPT is able to fit into the Blooms taxonomy](#) for learning objectives as a learner.

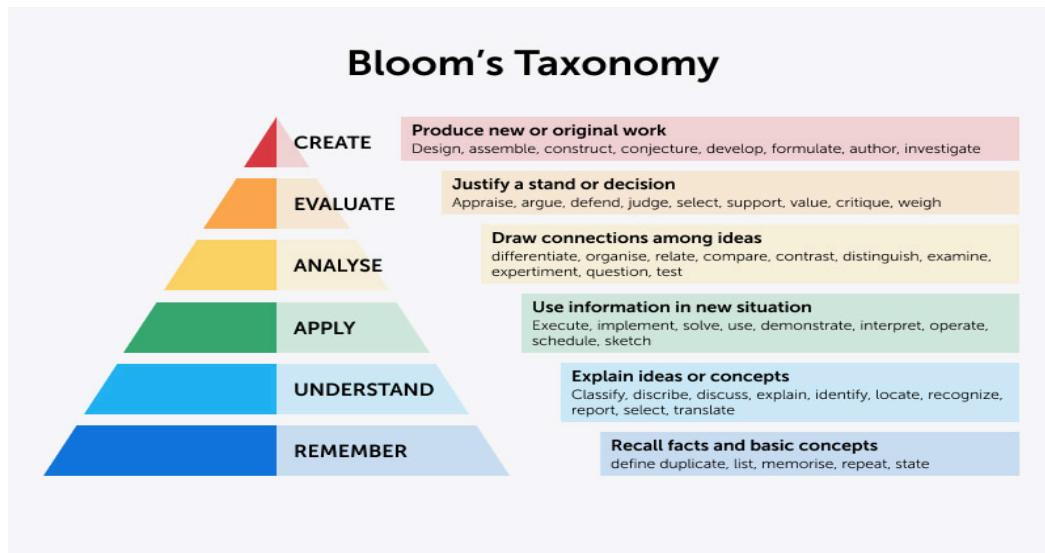


Figure 3.1: Bloom's Taxonomy ([ImageSource](#))

Remember:

- **Bloom's Level:** Remembering
- **GenAI's abilities:** Highly competent
- **Key actions:** Retrieving information such as facts, dates, definitions, or answers.

How well does AI recall data or information?

AI can simultaneously access millions of pieces of information across large databases. It will always be able to retrieve data more quickly, accurately, and with more abundance, than humans ever will.

Understand:

- **Bloom's Level:** Understanding
- **GenAI's abilities:** Gaining competence

- **Key actions:** Recognizing, describe, locate, discussing, or explaining the meaning behind information

How well does AI understand the information?

In my opinion, the recent GenAI models are capable of understanding the text better compared to previous models. Thanks to technology and recent architectural advancements in transformer models that enable the transformers to focus on the important components of the text so as to not just behave just like a rote learner but as to understand the patterns and formation of sentences. It is understood that AI can recognize patterns, categorize data, and extract pattern-based meaning from large datasets, but it doesn't truly "understand" in the human sense. Its comprehension is based on patterns and data, not on consciousness or intuition.

Though at this point of time one cannot say a technology like GenAI has accomplished understanding language. In my opinion, language is the most remarkable creation of humans and a complex creation too. A language model is constantly in the efforts to achieve understanding of language.

Apply:

- **Bloom's Level:** Apply
- **GenAI's abilities:** good competent
- **Key actions:** Use information in new situations. Solve, interpret, implement

Application of knowledge through learning and understanding the concepts of learned topics. For example in human capability, science concepts such as gravity can be used in its application of creating space crafts or aeroplanes. In the realm of GenAI the knowledge acquired by the model is very well applied in cases like Zero shot learning where the model is able to apply the concept of classification or image detection of unseen classes through application of an underlying logic or algorithm.

Another example would be the case of the Machine learning model which tries to apply the learned pattern on new test / inference data. The continuous goal of scientists is to make the machine to apply its acquired knowledge to applications in different areas , one such example is Transfer learning.

Analyze:

- **Bloom's Level:** Analyze
- **GenAI's abilities:** Highly competent
- **Key actions:** Use information in new situation

AI can analyze vast and multidimensional datasets with superhuman speed, identifying subtle patterns and relationships. For instance, in genetics, AI tools can sift through enormous genomic data to spot potential markers or mutations linked to diseases. AI can predict potential future patterns based on historical data, which makes it highly competent at this level.

Evaluate:

- **Bloom's Level:** Evaluate
- **GenAI's abilities:** Low competent
- **Key actions:** Use information in new situation

The process of evaluation extends beyond data-driven decision-making; it represents an intricate cognitive process that often requires judgment, ethics, and an understanding of context. At this point, AI faces limitations, lacking ethical judgment, cultural sensitivity, and emotions. Its reliance on quantifiable metrics overlooks the broader perspective, even though such metrics are valuable for identifying blind spots. In situations requiring instinct-based decisions, a strength of human leadership, AI falls short. The example of a decision to sell the stocks during a pandemic or a decision to launch a product evaluating the market trend all shows effectiveness of human intuition. Despite AI's incapacity for judgments, it excels in providing pertinent information and recommendations, enabling humans to make informed decisions.

Create:

- **Bloom's Level:** Create
- **GenAI's abilities:** surprisingly highly competent
- **Key actions:** Produce new or original novel work

Generative AI models are incredibly diverse. GenAI has clearly proved creating images, content, music, and poems which are the key areas of creative work.

However, one cannot deny the fact that these works created by GenAI are learned patterns, residual memory and mimicking the learned items. The final product may look unique but it's just one of the possible combinations of the mixture it produced from the learned data. Though AI is learned to create, what it lacks is originality and context.

Exploration 4 – Information Retrieval

Q6 – Faceted Search and physical organization

Choose a grocery store that you like and usually go to (Loblaws, IGA, Provigo, ...) and compare their physical organization with the faceted search that their online shopping provides. TO DO: Describe some aspects of the physical organization and its constraints. Highlight some aspects of the faceted search that are available. For a few grocery items (choose 3-4), describe the advantages/disadvantages of a physical versus a faceted search.

What is Faceted Search?

Faceted search, also known as **faceted navigation** or **faceted browsing**, is a technique used by eCommerce brands to help users analyze, organize, and filter large sets of product inventory based on filters such as size, color, price, and brand. Faceted search helps shoppers to eliminate everything they don't want by selecting all the features that are important.

Image Source: *Amazon*.

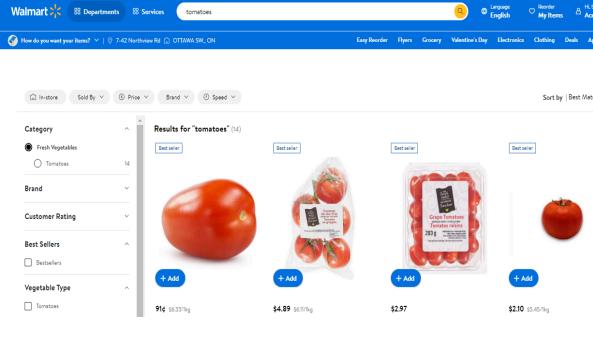
FACETED SEARCH allows shoppers to narrow search results using attribute filters

Product	Description	Price	Rating
Ashley Furniture Signature Design - Larkinhurst Rocker Recliner - Manual Reclining Chair - Traditional Style - Earth	by Signature Design by Ashley	\$489.00	4.5 stars (281 reviews)
Best Selling Leather Recliner Club Chair	by Best-selling	\$163.69 prime	4.5 stars (170 reviews)
Best Selling Davis Leather I Club Chair, Black	by Best-selling	\$125.99 prime	4.5 stars (315 reviews)

Comparison of Faceted Search and Physical organisation:

The grocery store I choose to compare the faceted search and physical organization is [Walmart](#).

Faceted Search:	Physical Organisation:
<ul style="list-style-type: none"> ● Organization is achieved as facets such as product category, brand, price etc <p>Example:</p> <p>We are looking for some tomatoes we can have several facets such as vegetable type, organic, country produced etc</p>	<ul style="list-style-type: none"> ● Organization is achieved as aisles, shelves, and physical displays. <p>Example:</p> <p>Tomatoes of all varieties are arranged at same section to compare and also to access easily.</p>

	
<p>● The search and finding the items to buy is more of exploration. Structured search experience with filter options enables the user to explore various brands and drill down to see more available options.</p>	<p>● In terms of physical store its more of self exploration with available knowledge at display station or checking with the support staff</p>
<p>● Faceted Store Organization: Requires less resources in making changes to the facets or organization structure as its online and changes to be made to online portal. Flexible for shop owners and cost effective mode of commerce when compared to physical organization.</p>	<p>● In-store organization is less flexible compared to faceted search. Once a product is placed in a certain aisle or section, it may be challenging to adapt quickly to changes</p>
<p>Convenience: ● Efficient way of shopping for products as there are several details available for the customer to know about the product. Customer can see images, compare with other brands , compare price range more conveniently</p>	<p>Convenience: ● Exploring aisles and discovering vegetables, checking quality and variety is a manual process which could be little exhausting especially walking in huge super stores.</p>

Limitations of Instore organization:

Store Layout : The overall arrangement of departments, aisles, and product displays to guide customer flow is a labour intensive job. Also store have space limitations based on the available floor space may restrict the number and size of departments.

Managing inventory Stocks and maintenance: Management of stocking and restocking activities while maintaining a clean and organized shopping environment.

Product organizing / Categorization : Grouping similar products into departments or sections for organizational clarity. Poorly arranged or hidden departmental divisions may make it difficult for customers to locate specific categories.

Highlights of Faceted search:

To highlight the features of the faceted search in the walmart website, let's look for an item in the website, "say cheese". Figure below shows the different facets that appear while searching for the item cheese.

Facet Selection:

Users can choose from various facets or categories such as category, brand, cut customer rating, best seller, lifestyle and dietary requirement,cheese type, sold-by as shown in the figure above.

Price Range Filters:

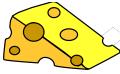
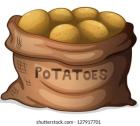
Users can set a specific price range to narrow down the search results based on their budget.

Product subjective Filters:

Some filters subjective to the product like Cheese type, lifestyle and dietary needs are specific to the product that is unique and dynamic.

Image source : [walmart](#)

Comparing the instore organization and faceted search of 4 grocery items at walmart.

Grocery Item	Aspect	Instore Organization	Faceted Search
	Advantages	Customers can touch and smell different cheese varieties, assessing their texture and aroma	Online platforms can provide extensive details on cheese types, origins, flavor profiles, and pairing suggestions.
	Disadvantages	Limited information, dependency on staff	Users miss the opportunity to physically assess and have only limited personalized advice
 <small>shutterstock.com 127912791</small>	Advantages	Customers can visually inspect and select potatoes based on size, quality, and variety allowing quick decision making	Users can quickly find specific types (e.g., russet, red, sweet) and filter by organic options
	Disadvantages	In-store information may be limited to basic details, such as potato type and origin.	Users cannot physically inspect potatoes for freshness and quality
	Advantages	Customers can visually inspect the freshness and quality of fish at the seafood counters	Online platforms can provide information on fish type, origin, sustainability, and cooking suggestions.
	Disadvantages	In-store information may lack details on the fish's origin, sustainability, or specific characteristics. Availability of expert advice depends on the presence of knowledgeable staff	Users cannot visually assess the freshness or appearance of the fish. Online freshness may be influenced by delivery times and conditions.
	Advantages	Customers can check the expiration date on milk cartons for freshness as well visually inspect the packaging for organic certification.	Online platforms can showcase a variety of organic milk types, brands, and packaging sizes. Users can also filter by factors like fat content, brand, and size.
	Disadvantages	Limited variety, dependency on stock	Inability to check freshness, dependency on delivery

Q7 – Search Box and Tagging

As programmers, you have certainly been on the Stack Overflow site (<http://stackoverflow.com>) to find answers to some programming issues. Take some time to look a bit at their knowledge organization.

TO DO:

Look at their search box. It's as if they partially included a faceted search within the search box. What do you think about that approach? How is it different from a faceted search?

We think that the partial faceted search that they included is an interesting approach. It allows users to get specific with what kind of search result they want, filter out questions that have not yet received an accepted answer, or those that do not have a high enough score, and so much more, in a simple, easy-to-use manner. It is different from a faceted search because it is like a full-text search with the options to add additional filters for certain facets. It is thus a hybrid approach. Additionally, unlike other faceted search systems, there is no list of menus that the user has to click on in order to filter out facets, but instead this is done directly with the search query. The average user of StackOverflow is familiar with some sort of programming, and this is very similar to how one would filter out values in a database, for example, with a SQL query. Hence, it might be quicker and more familiar to the target users. For a non-programmer, this might seem less user-friendly, and they might prefer something like a proper faceted search system.

Look at their synonym table. Why do they need to provide such a list?

The synonym table is provided because many tags might refer to the same concept (e.g. "arrayofarrays" vs "multidimensional-array") or to different versions of the same software (e.g. "pandas" vs "pandas-1.x" vs "pandas-2.x"), or a pair of tags might be so similar to each other that it makes more sense to group those posts together (e.g. "404-page" vs "custom-error-pages"). This makes it easier for users to find what they are looking for especially if they explicitly specify the tag within their search. StackOverflow provides such a list so that users know that adding multiple related tags will not help. It could also provide guidance for specifying a tag.

Does the list of tags seem like a taxonomy or folksonomy? Explain.

There is no concrete hierarchical structure that these tags follow, and nor is there any expert knowledge used in creating a large hierarchical organization of tags. The tags are contributed by individual users. Users are given the option to add a tag as long as they receive approval and they have tagging privileges. For these reasons, this is not a taxonomy, but rather a folksonomy.

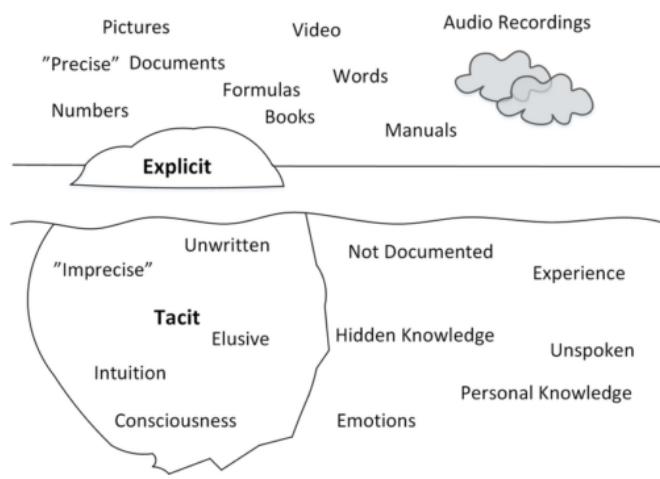
Do you feel that their knowledge organization meets users' needs? Give some examples

In terms of meeting users' needs, we feel that it adequately allows users to filter by the facets that they find relevant, as explained before. For example, if a user wants to know why their Python class is not inheriting from another class, they can type out the question and add the additional tag "Python" so that it does not give them information from another programming language which might not be relevant to their question. If the user has a rare problem that does not have a well-known solution, they can add "isaccepted:yes" to their search query so that only questions where the author was satisfied with a solution would show up in the search results. Further, most people reach StackOverflow through Google searches of their bugs rather than through the site directly. Therefore, having the support of a more advanced faceted search would only be marginally more useful, and as such, the current search functionality adequately meets users' needs.

Exploration 5 – Knowledge Management

Q8a – Tacit/Explicit Knowledge (2 points)

Think of going through your undergraduate studies, what you learned can be split into tacit knowledge and explicit knowledge. TO DO: Provide examples of each type of knowledge.



Tacit knowledge is implicit knowledge that is gained through experience, insights, intuition and is very subjective and personal to a person. This knowledge is unwritten, undocumented and is often hard to be communicated or shared to others. **Explicit knowledge** on the other hand, is streamlined , structured, formal, objective, and can be written down easily. It's the type of information you typically find in books or documents([ImageSource](#)).

Explicit knowledge in OOP:

In the case of my undergraduate studies, there were several academic subjects. The one that interested me was Object Oriented Programming (OOP). Explicit knowledge in OOP is represented by the well-documented syntax, rules, and concepts of a programming language. It includes language specifications, design patterns, coding conventions, and API documentation. Explicit knowledge in OOP can be found in textbooks, online tutorials, and official language documentation.

Example: A clear understanding of how to declare classes and objects, the use of inheritance, polymorphism, encapsulation, and abstraction in OOP is explicit knowledge. It is typically gained through studying programming languages and their documentation.

Tacit Knowledge in OOP:

In OOP: Tacit knowledge in OOP involves the intuitive understanding of how to design efficient and effective class structures, make appropriate use of inheritance, and create reusable and maintainable code. It includes the ability to make design decisions based on experience and an understanding of real-world problem-solving using OOP principles.

Example: Knowing when to use composition over inheritance, designing classes with a focus on cohesion and loose coupling, and making decisions on class hierarchies based on the specific requirements of a project are examples of tacit knowledge that I gained while I was implementing OOP in C#.

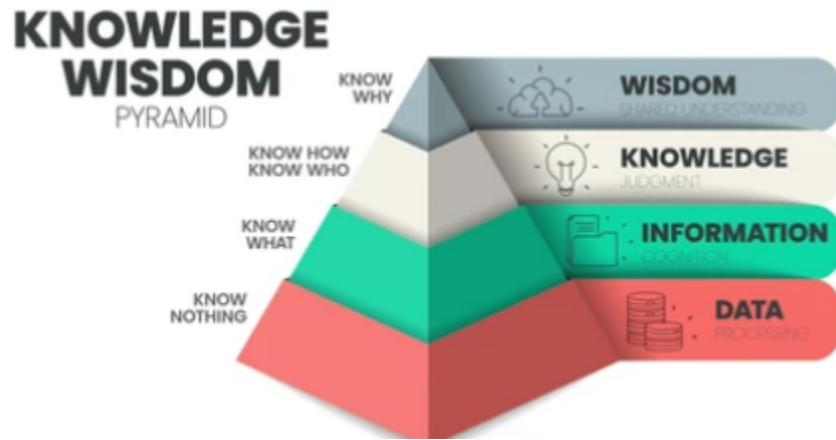
The table below shows the comparison between tacit and explicit knowledge.

Tacit knowledge	Explicit knowledge
<ul style="list-style-type: none">- Gained through experience- This is subjective and cognitive- This knowledge is difficult to write down, visualize share or articulate- Examples: Troubleshooting, research, process improvement, trial and error	<ul style="list-style-type: none">- Knowledge that is structured, documented and easily defined- This is Objective and rational- Can be easily and readily identified, accessed, shared and communicated to others- Examples: Cookbooks, maps, manuals, handbooks,

Q8b – DIKW (3 points)

In DIKW, a situation can be analyzed in terms of Data perceived, Information constructed, Knowledge acquired from contextualizing the information and Wisdom of what to do (how to act/react). TO DO: Continuing in our grocery store topic... Describe the process of going to the grocery store and buying what you need for your dinner, providing examples for each of the steps (Data, Information, Knowledge, Wisdom).

The process of going to the grocery store and buying items for dinner using the DIKW (Data, Information, Knowledge, Wisdom) framework:



([ImageSource](#))

Task: *Making Pasta for dinner*

Data (Perceived):

Example:

- Check the ingredients required to make pasta.
- The kind of cheese required - { Parmesan, Mozzarella, blue cheese , cheddar}
- Pasta type - { Penne, Fettuccine , Spaghetti}
- Observing what is available in the refrigerator that is running low on stock such as cheese, tomatoes, onion, pasta, and milk.

Information (Constructed):

Example: Compile a list of grocery items needed for dinner: cheese, tomatoes, onion, pasta, and milk to be purchased from the grocery store. These items can be purchased online using faceted search to select the correct ingredients.

Check store timings to source the items prior

Knowledge (Acquired from Contextualizing Information):

Example: The application of knowledge is considering factors like dietary preferences, the type of pasta dish that we want to prepare, expiration dates, and quantity needed based on the number of people dining. This knowledge helps us refine the list and prioritize items.

Wisdom (What to Do - How to prepare dinner):

Example: With the refined list, and collect the items organized based on the store's layout to save time. We can also check for any ongoing promotions or discounts on these items, making informed decisions on where to buy. Additionally, wisdom is also choosing to buy organic products based on your values. Section ([Question 6](#)) explains the pros and cons of using faceted search or choosing to visit a grocery store to buy the items. The importance of wisdom here also could be knowing the fine details of the items to buy so that the pasta is made with the best quality ingredients or using our wisdom to decide to buy at store or shop at the portal..

Review of the framework:

Data: Low stock of cheese, tomatoes, onion, pasta, and milk in the refrigerator.

Information: Compiled list of items needed for dinner - cheese, tomatoes, onion, pasta, and milk.

Knowledge: Consideration of dietary preferences, allergies, type of pasta dish, expiration dates, and quantity needed.

Wisdom: Organizing the shopping list based on store layout, checking for promotions, and making informed decisions based on personal values.

In this way, the DIKW framework helps illustrate how a simple task, such as going to the grocery store, involves progressing from raw data to acquiring knowledge and, ultimately, applying wisdom in making decisions during the process.

Exploration 6 – Computer Science

Q9 – Heuristics

There are situations in life in which we prefer to use heuristic knowledge taught to us than go the full try/error empirical way (gathering positive and negative examples and learn from them).

For example, as a student, you could experiment and see what leads to failing and succeeding in exams over the years, but that takes a while and the consequences are not great. Instead, you might want to use/develop heuristic knowledge.

TO DO:

Describe 5 heuristics you personally use in order to succeed in an exam (perhaps these heuristics were gathered through your years as student). You can express these heuristics as rules, or just describe them in sentences.

The fully empirically tested way to succeed in an exam is to know all the material thoroughly and to make sure everything has been practiced. In an ideal world without time restrictions and other commitments, this would be the perfect strategy to use. We do not, however, live in an ideal world, and must use heuristic knowledge to score well on an exam. The following are 5 heuristics that we personally use for exam success:

1. **Focus on the most important topics.** If the instructor has covered topics A, B, and C in class, but has constantly focused on topic C by covering many practice questions from topic C in class, or spending a lot of time talking about topic C, then it is likely that topic C is more important from the perspective of the exam.
2. **Focus on more recently covered topics for cumulative exams.** If an instructor covers topics A to F in the first few weeks of the term and conducts a midterm on these topics, and then covers topics G to L for the last few weeks of the term and conducts a cumulative final exam covering topics A to L, then it is very likely that the final exam will put greater emphasis on the more recently covered topics G to L.
3. **Do not start studying for an exam from the beginning of the term, but rather, start just one or two weeks before the exam.** We have found that if we start studying for an exam very early, we slowly forget the material, and have to spend the same amount of time reviewing the same material a week before the exam. Instead of spending double the time studying, we have found that it is better to just start studying a week or two before the exam so that the material is

still fresh in the mind, and we can obtain almost the same grade (perhaps slightly lower) with just half of the study time.

4. If an exam is only worth a small percentage of the grade, do not spend much time studying for it. Students often take multiple courses at the same time and if a particular exam is just worth 5% of the grade for example, it is probably a better use of their time to focus on something else and to just recall from memory the material covered during the lecture in order to write the exam. Even if the exam goes badly, 5% is not a huge dip in the final grade and one can still get an A+ if all the other components of the grade are good.

5. Skip any question that you are struggling to answer after spending more than a few minutes on them. If too much time is spent on a difficult question, that leaves less time to finish the remaining questions. As a result, even if you know the answers to all the remaining questions, your grade will not reflect this if you do not dedicate enough time to finishing all the parts of the exam that you are confident with. If there is still time left at the end, you could always return to the questions you were struggling with and spend more time thinking about the answer.

Ask some friends what heuristics they use to succeed in their exam. Compare with yours. Are they similar? Discuss.

After discussing with two friends, our heuristics 1 and 2 are very similar to theirs. Additionally, here are some of the other heuristics they use:

1. In multiple choice questions one of them just selects C for all the remaining questions if he does not have enough time to finish the exam. An answer should have a roughly 25% chance of being correct if there are 4 choices in the test.

- We agree with the idea of guessing when unsure, but are not sure if C is the right choice. A or B might be better since some questions could be "true or false" based, where only 1 in 2 choices is correct, so perhaps A or B would be a better safe-choice when running out of time.

2. One friend pulls "all-nighters" where he starts studying for exams the night before, and often does not sleep but spends the whole night just studying the material. He asserts that since the material is very fresh in his mind, he thinks he will do well on the test. He says this method saves time since he only needs to dedicate a few hours to studying.

- We do not agree with this idea at all. From an exam perspective and also from a learning perspective, this is a terrible way to remember information as it is a well-known biological fact that sleep aids in memory. Lack of sleep causes similar cognitive impairment as being drunk (Williamson & Feyer, 2000). One would not want to write an exam while drunk, so why would writing an exam while being sleep-deprived be acceptable?

References

- Williamson, A. M., & Feyer, A. M. (2000). Moderate sleep deprivation produces impairments in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication. *Occupational and environmental medicine*, 57(10), 649–655.
<https://doi.org/10.1136/oem.57.10.649>

Q10 – Knowledge types

We saw 5 types of knowledge: declarative, procedural, structural, heuristic, meta. All these types of knowledge would be present in most situations. In intelligent farming, for example, we can imagine having drones to photograph fields and analyse the readiness of the crop.

TO DO: Provide examples of each type of the 5 types of knowledge that the drone could use. Even if you don't know much about farming, you can provide explanations of your own ideas. The purpose is to differentiate between the types of knowledge.

Use case: [Applications of Drones in Smart Agriculture](#)

The application of drones in agriculture has opened-up a new horizon to increase the agriculture outputs and real-time access to high-quality information. Drones can assist in precision agriculture by performing a variety of agricultural tasks including soil health monitoring, seed planting, fertilizer application, crop stress management, irrigation schedule planning, weed management, crop yield management, and weather analysis [[Ref 10.1](#)].

Declarative Knowledge:

Declarative knowledge is the AS-IS knowledge and the concepts, facts about the event/ thing. This is in simple language and contains more factual information. In the case of Drones when applied in intelligent farming, the declarative knowledge would be to know the facts about several things involved in farming [[ref](#)]. The declarative knowledge the drone can acquire before are,

- **Farm land area** - The area under surveillance. For instance total hectares of land, specific zones within the farm
- **Crop type** - The type of crop under vegetation. For example, this can give some facts to the drones about the crop, crop rotation cycle, identify the crops
- **Soil type** - Details about the soil such as Information about the characteristics and composition of the soil in different parts of the farm. The drones can know about Soil pH levels, Soil texture (silty, sandy, loamy, clayey), Organic matter content.
- **Possible hazards** -Knowledge about potential risks or threats to the crops or the farm. Identification of pests and diseases and being aware of Awareness of weather-related hazards (storms, frost)
- **Fertilizer requirements** - Information about the nutritional needs of the crops. This includes type of fertilizer for crop, Fertilizer quantities
- **Yield period** - Knowledge about the typical duration for crop maturity and harvesting.

Procedural Knowledge:

Procedural knowledge is a type of knowledge which is responsible for knowing how to do something. It can be directly applied to any task. It includes rules, strategies, procedures, agendas.

In the case of intelligent farming the drone should be fed with procedure to perform several tasks. The [article](#) describes the activities of drones in agriculture which includes soil assessment, crop analysis, data collection through its sensors, softwares, cameras. The procedural knowledge the drones require are,

- **Crop Analysis Procedures**- Processes to analyze crop health and growth. The drone should be capable of processing captured images to identify crop types and assess vegetation health
- **Soil Assessment Procedures** - Steps to assess soil characteristics and to determine the fertilization requirements
- **Fertilization Procedures** - Steps for applying fertilizers based on crop and soil requirements
- **Navigation and Surveying Procedures** - Processes for efficient movement and surveying of the farm

Heuristic Knowledge:

Heuristic knowledge is representing knowledge of some experts in a field or subject.

These are rules of thumb based on previous experiences, awareness of approaches, and which are good to work but not guaranteed.

In the context of a drone used for smart agriculture, heuristic knowledge involves rule-of-thumb strategies or approaches to problem-solving.

- **Selective Image Capture for Pest Identification** - The Heuristic Knowledge would be the drone could employ a heuristic to selectively capture images in areas prone to pest infestations based on temperature, humidity, and historical pest data
- **Selective Fertilizer Application** - the Heuristic Knowledge would be the drone might use heuristics to recommend selective fertilizer application based on observed variations in soil nutrient levels.
- **Sampling for Soil Assessment** - The Heuristic Knowledge would be the drone may employ a heuristic to dynamically adjust soil sampling density based on observed variations during flight.

Meta Knowledge:

Knowledge about the other types of knowledge is called Meta-knowledge. In the smart agriculture example. The data used by drones are from various technology and tools about the crop, soil and other details of the vegetation. The meta data in this case could be the version of the software used in the drone, the manufacturer of the fertilizer, the country where the crop is imported. Few more examples of meta data would be the precision of the aerial camera used in taking pictures, year of manufacture of the camera and so on.

Miracle-Gro AeroGarden Liquid Plant Food 4-3-6 1LITER (33.81 FL OZ) NET Wt 2.46 lb (1.12 kg) GUARANTEED ANALYSIS Total Nitrogen (N) 4.0% 1.0% Ammoniacal Nitrogen 3.0% Nitrate Nitrogen Available Phosphate (P ₂ O ₅) 3.0% Soluble Potash (K ₂ O) 6.0% Calcium (Ca) 1.0% Magnesium (Mg) 0.5% 0.5% Water-Soluble Magnesium (Mg) Derived from: Potassium Nitrate, Calcium Nitrate, Mono Potassium Phosphate, Ammonium Nitrate and Magnesium Sulfate. Information regarding the contents and levels of metals in this product is available on the internet at http://www.aapfco.org/metals.htm <i>In Mississippi this is classified as a low-analysis fertilizer.</i>	249g • 4K HDR Video • FocusTrack DRONE Maximum speed 16 m/s (S mode) - 10 m/s (N Mode) - 6 m/s (C Mode) Maximum flying height 4000 meters Maximum flight time 34 minutes (Standard battery) Max. flight distance 18 km Max wind resistance 29 to 38 km/h (level 5) CAMERA Wi-Fi 802.11 a/b/g/n/ac Bluetooth 5.2 Operating temperature 0 to 40°C Global Navigation Satellite System (GNSS) GPS + Galileo + BeiDou Sensor 1/1.3" CMOS / Effective pixels: 48 MP Lens FOV: 82.1° / Equivalent format: 24 mm Aperture: f/1.7 / Range: from 1 m to ∞ Video 4K / 2.7K / FHD / Slow Motion: 1920 x 1080 QuickShot Dronie, Rocket, Circle, Spiral, Asteroid, Boomerang
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Image showing the information about a fertilizer. This is an example of metadata ([ImageSource](#)). Second image showing the specification of the camera and drone itself([ImageSource](#)).

Structural Knowledge:

Structural knowledge is basic knowledge of problem-solving. It describes relationships between various concepts such as kind of, part of, and grouping of something. It describes the relationship that exists between concepts or objects. This combines the declarative and procedural knowledge to make decisions.

Smart Farming with Drones: Revolutionizing Crop Monitoring and Management. In the process of collecting the real time data from various sources such as cameras, sensors. The drones form their structural knowledge from the declarative and procedural knowledge it has gathered to apply them in order to make decisions. With accurate and timely information and decisions about the state of their crops, farmers can apply fertilizers and treatments precisely where needed, avoiding unnecessary resource wastage and reducing environmental impact.

For example, The [Power of Early Detection](#) - The significance of early pest detection cannot be overstated. Detecting pests before they multiply and spread allows for targeted interventions, reducing the need for blanket pesticide application. This precision not only minimizes environmental impact but also safeguards beneficial insects and pollinators that are essential for ecosystem health. This is an excellent example of the structural knowledge the drone in our use case can bring out.

Exploration 7 – Symbolic AI

Q11 – Definitions

Choose a noun X that would have at least 2 meanings. We call that a polysemous word.

The chosen noun is 'mouse', which refers to the small rodent or the device used to control the cursor on a computer.

For each meaning, find 3 definitions coming from different dictionaries.

Build a comparative table in which you show for each meaning what is being suggested as genus and differentia in each dictionary.

Note that some dictionaries provide more than 2 definitions, but the one with the meaning closest to the above 2 definitions were selected. More definitions were not presented below because some of the definitions do not have a corresponding pair in the other dictionaries. For example, one meaning of mouse is "a lump or bruise, especially one on or near the eye" according to Google Dictionary, but this definition is absent from Cambridge Dictionary.

The following table presents the dictionary definitions for both meanings from each of the three dictionaries that have been used - Dictionary.com, Google Dictionary (powered by Oxford Languages but with images provided by Google), and Cambridge Dictionary. Below each definition, we have included what is being suggested as genus and differentia.

	Mouse as a small rodent	Mouse as a computer accessory
Dictionary.com	any of numerous small Old World rodents of the family Muridae, especially of the genus <i>Mus</i> , introduced widely in other parts of the world.	<i>Computers</i> . a palm-sized, button-operated pointing device that can be used to move, select, activate, and change items on a computer screen.: Compare joystick (def. 2), stylus (def. 3).
	Genus: any of the numerous small rodents from the family Muridae Differentia: no differentia because it is an intentionally broad category	Genus: a computer accessory (suggested by the italicised 'Computers') Differentia: a palm-sized, button-operated pointing device that can be used to move, select, activate, and change items on a computer screen

Google Dictionary	<p>a small rodent that typically has a pointed snout, relatively large ears and eyes, and a long tail.</p> <ul style="list-style-type: none"> ● (in general use) any small mammal similar to a mouse, such as a shrew or vole. ● a shy, timid, and quiet person. "Jane may be a bit of a mouse, but she is very nosy" ● a dull light brown color reminiscent of a mouse's fur. "her blonde hair dulled to mouse" 	<p>a small handheld device that is dragged across a flat surface to move the cursor on a computer screen, typically having buttons that are pressed to control functions.</p> <p>"copy the file with a click of the mouse"</p> 
	<p>Genus: a small rodent Differentia: the fact that it typically has a pointed snout, relatively large ears and eyes, and a long tail</p>	<p>Genus: a small handheld device Differentia: the fact that it is dragged across a flat surface to move the cursor on a computer screen, typically having buttons that are pressed to control functions.</p>
Cambridge Dictionary	<p>a small mammal with short fur, a pointed face, and a long tail:</p> <ul style="list-style-type: none"> ● a field mouse ● a pet mouse 	<p>a small device that you move across a surface in order to move a cursor on your computer screen</p> 
	<p>Genus: a small rodent Differentia: having short fur, a pointed face, and a long tail</p>	<p>Genus: a small device Differentia: the fact that you move the device across a surface in order to move a cursor on a computer screen</p>

In a few sentences, analyse the information that you put in your comparative table. What do you think? Do you prefer some definitions over others? Why?

All three of the chosen dictionaries are well-reputed sources, but the definitions they provide differ significantly.

For the case of the rodent definition of the word 'mouse', Dictionary.com does not provide any differentia, while both Google Dictionary and Cambridge Dictionary provide physical attributes to help differentiate mice from other small rodents, which in our opinion, would be more useful for the average user of the dictionary. The Cambridge definition even provides a helpful image. However, in terms of scientific accuracy as per biological taxonomy, Dictionary.com might actually be more accurate since it is quite appropriate to use the word mouse for a variety of rodents that have the characteristics of the family Muridae. This is a case where more accurate does not necessarily mean more useful.

For the case of the computer accessory definition of the word 'mouse', both Google Dictionary provides a more general genus of a handheld device, while Dictionary.com just specifies that it is a computing accessory. All of them have extremely similar differentia, describing how the device is used. Cambridge Dictionary's definition just specifies that a cursor can be moved on a screen but Dictionary.com mentions what one can do when moving the cursor, viz., move, select, activate, and change items on a computer. In terms of usefulness, we believe that all three definitions are roughly equivalent when considering both the genus and the differentia. The only additional information provided by both Google Dictionary and Cambridge are the images which make the definitions easier to understand.

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Dictionary.com. Mouse definition & usage examples. Dictionary.com. Retrieved February 1, 2024, from <https://www.dictionary.com/browse/mouse>

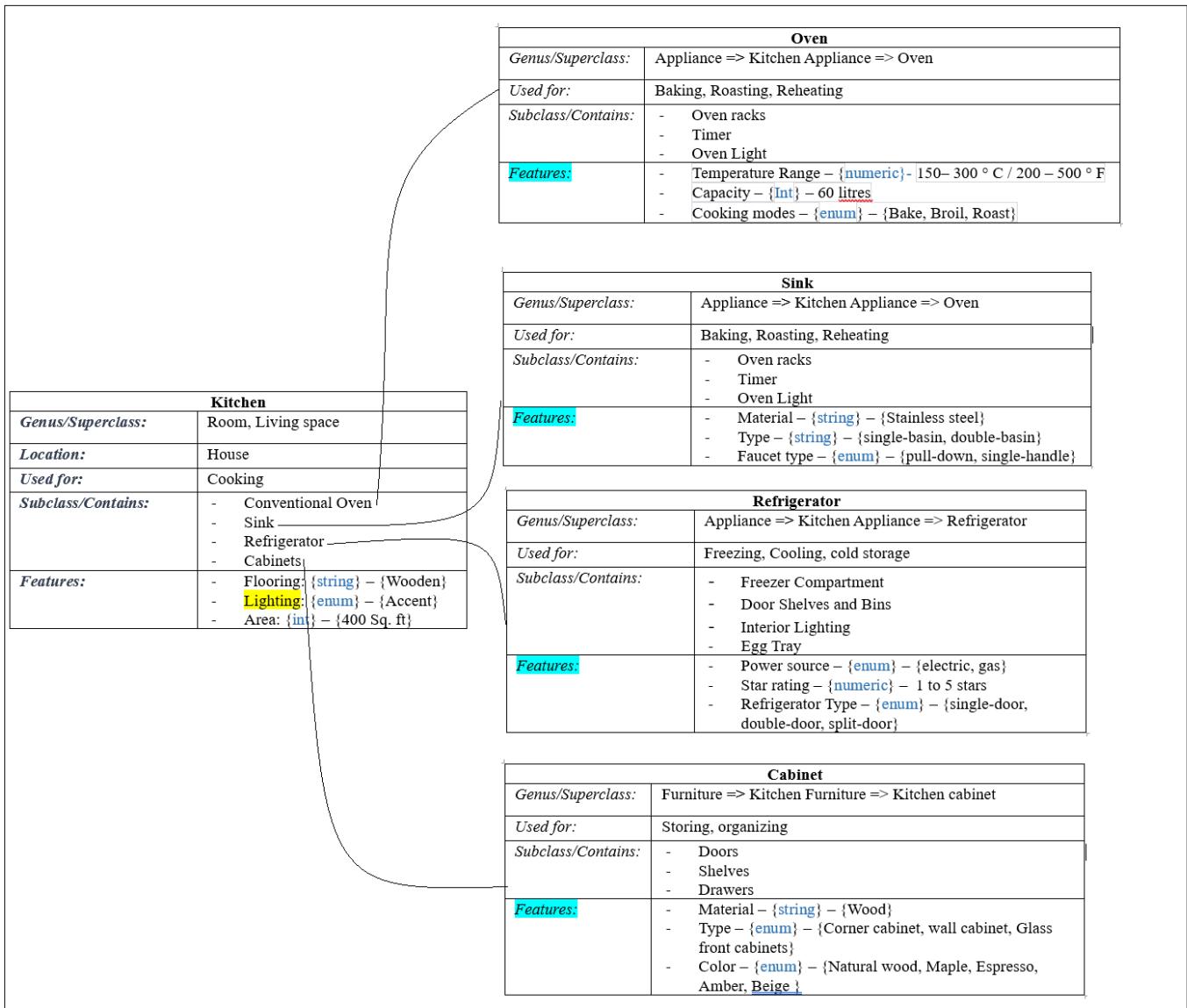
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Q12 – Frames

Frames can be defined for anything. Imagine describing a kitchen which contains a refrigerator, sink, oven, cabinets.

TO DO: Develop the 5 frames (with their frame elements) to correspond to the five words: kitchen, refrigerator, sink, oven, cabinets. For each frame, include at least 3 descriptive slots (features), one genus slot (superclass), and one procedural slot (e.g. used for). For each descriptive slot, provide the range (e.g. integer, enumeration).



Exploration 8 – Data-driven AI

Q13 – Data labeling

As mentioned in class, there are many data labeling services.

TO DO:

Further explore 4 services of your choice and compare them. Include at least one that is crowdsourcing.

Gather information about these 4 services:

- **Do they offer the same kind of service?**
- **For what tasks?**
- **Do the people doing the annotation have any expertise?**

Present a comparative table of the 4 services explored. In your comparative table, there should be at least 5 criteria for comparison. 3 out of 5 criteria can be the 3 questions above, and you can add 2 other criteria of your choice.

The four services explored are Amazon Mechanical Turk, Scale AI, Clickworker, and Appen. All of these offer data labelling services, but differ in their specialization, expertise of crowds, domains, etc. The following table compares them based on 5 criteria (including the 3 criteria presented in the question) using information from their official websites (cited).

	Amazon Mechanical Turk	Scale AI	Clickworker	Appen
Do they offer the same kind of service?	Provides a 24/7 globally distributed workforce to perform Human Intelligence Tasks (HITs), involving data labelling, but also several similar tasks like content	Provides data labelling by combining AI-based techniques with human intervention for quality control. They also offer other end-to-end solutions to manage the	Provides crowdsourced data labelling and also data creation. Also offers survey filling, SEO creation, web research, and other similar features.	Provides data annotation with machine-learning assisted data-labelling where data points with low model confidence are sent for human-annotation. Also provides

	moderation, market research, surveys, etc.	machine learning lifecycle.		data generation with crowdsourcing.
For what tasks?	Users can customize jobs to theoretically request any possible Human Intelligence Task (HITs) as long as there is a worker willing to perform the task, and no platform policy is violated. Therefore, all annotation services are supported, including image, audio, video, text, etc.	Video (frame-by-frame annotation), Images (bounding boxes), text (OCR transcription), audio (transcription), map data (labelling of roads, lanes, areas, etc.), 3D environment annotation, etc.	Video (creation, categorization & analysis), images (creation, analysis, extraction, and classification), text (creation, including handwritten), audio (creation, transcription, commentary, classification of emotion tonality, topic, equality, etc.)	Video (frame-by-frame labels), images (labels on bounding boxes, cuboids, lines, segmentation, etc.), text (duplicate detection, transcription, classification, etc.), document (tables, OCR, etc.), audio (transcription, segmentation, speaker assignment, etc.), etc.
Do the people doing the annotation have any expertise?	Can request for workers with expertise, but requires a higher fee.	Yes (not crowdsourced)	Option to have managed service where crowdworkers pass a test before annotating (requires higher fees).	Option to have managed service with experts.
Pricing	User-specified, as long as a worker agrees to perform the job at the given	Starting prices: Image -\$0.02 per image plus \$0.06 per annotation, Video - \$0.13	For most tasks, it is user-specified, as long as a worker agrees to	User-specified price per page, with total cost calculated with formula:

	price. 20% MTurk fee, plus additional fees for workers with more expertise.	per frame plus \$0.03 per annotation. Text - \$0.05 per task with \$0.03 per annotation Document - \$0.02 per task with \$0.07 per annotation. Custom pricing for other tasks, for enterprise clients vs academia clients, etc.	perform the job at the given price, plus 40% service fee	(Judgments per row * (Pages of work * Price per page)) + transaction fee + buffer = estimated job cost Fixed transaction fee of \$3, regardless of total cost.
Data Privacy	Highly Secure. Follows the same data security practices as Amazon.	Highly Secure. Compliant with industry best practices and framework including SOC 2 Type II, DoD IL4 Provisional Authorization, and ISO 27001	Secure. Training provided to workers to keep data secure.	Highly Secure. Secure Data Access requirements met. Complies with GDPR, SOC 2 Type II, ISO 27001, and HIPAA

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