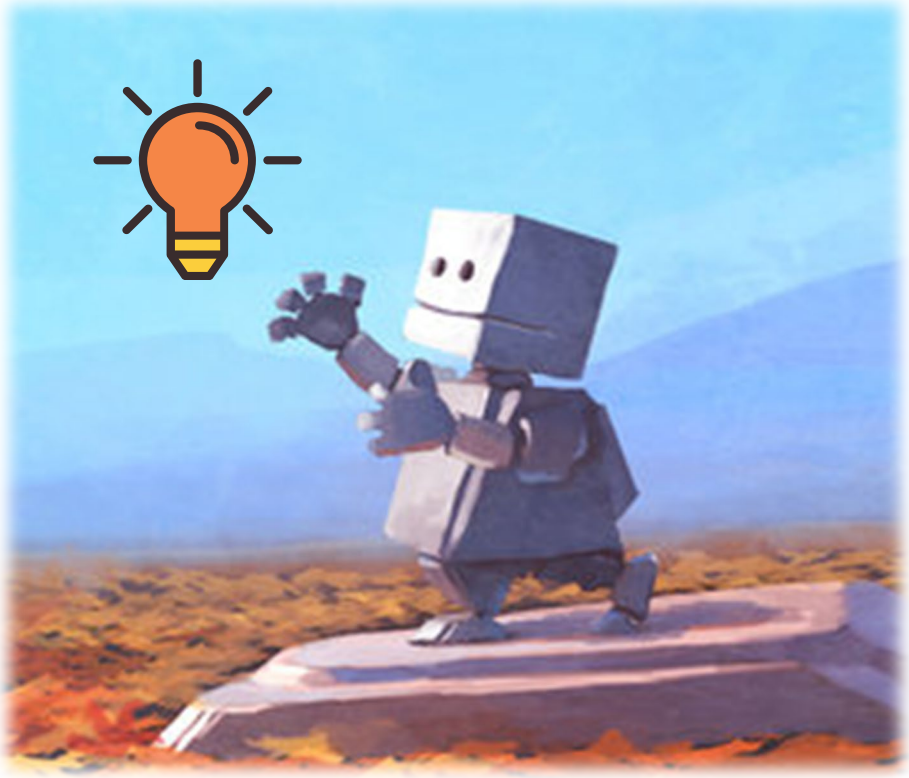
InnoVAE: Generative AI for Patents, Innovation, and Firms

Paper at: tiny.cc/innovae

Zhaoqi Cheng	**Boston University**
Dokyun “DK” Lee	**Boston University**
Prasanna “Sonny” Tambe	**UPenn**



Generative AI

Overview

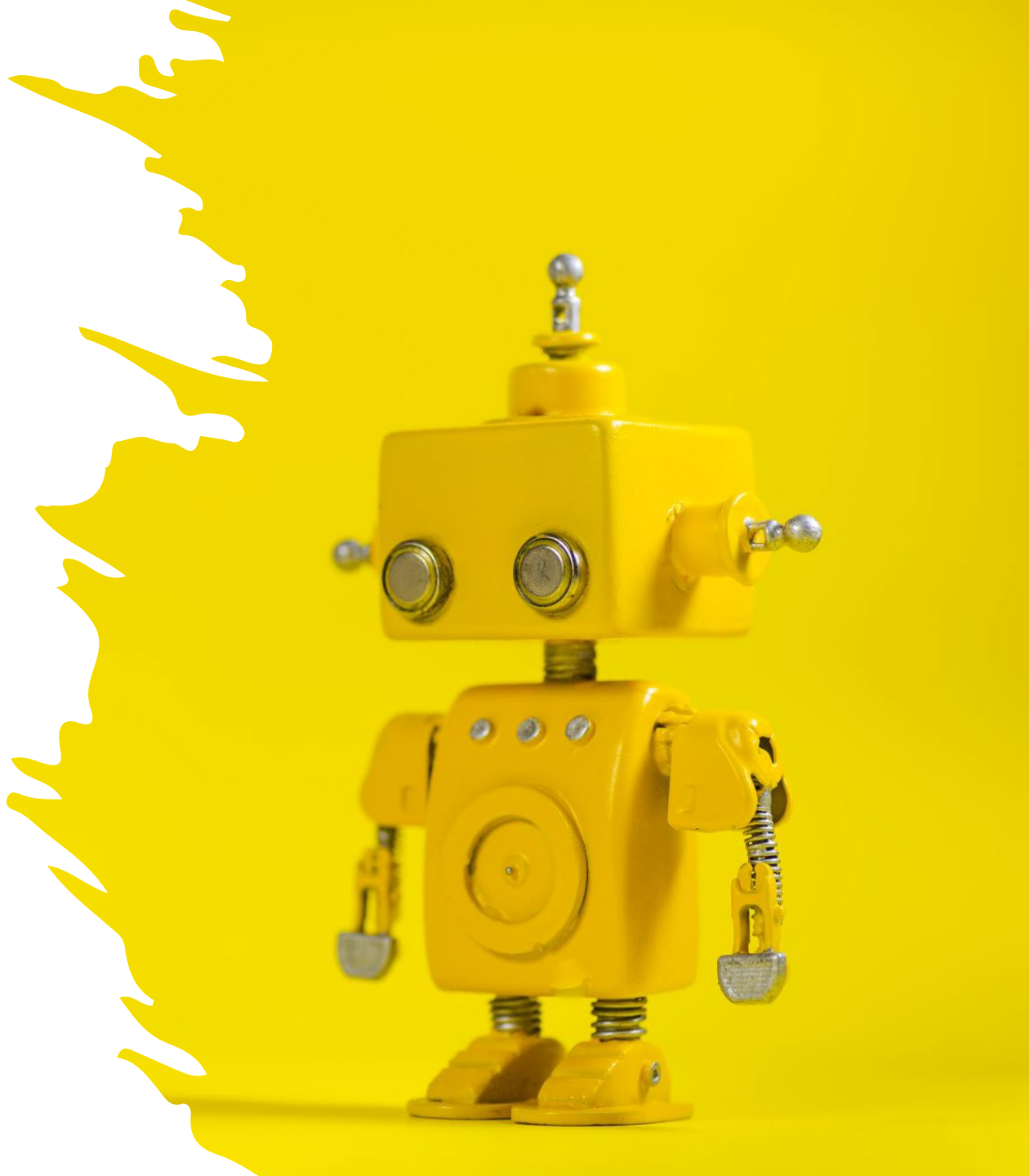
Midjourney | "Generative AI"

What is Generative AI?

Models data generating process.
It generate things ☺

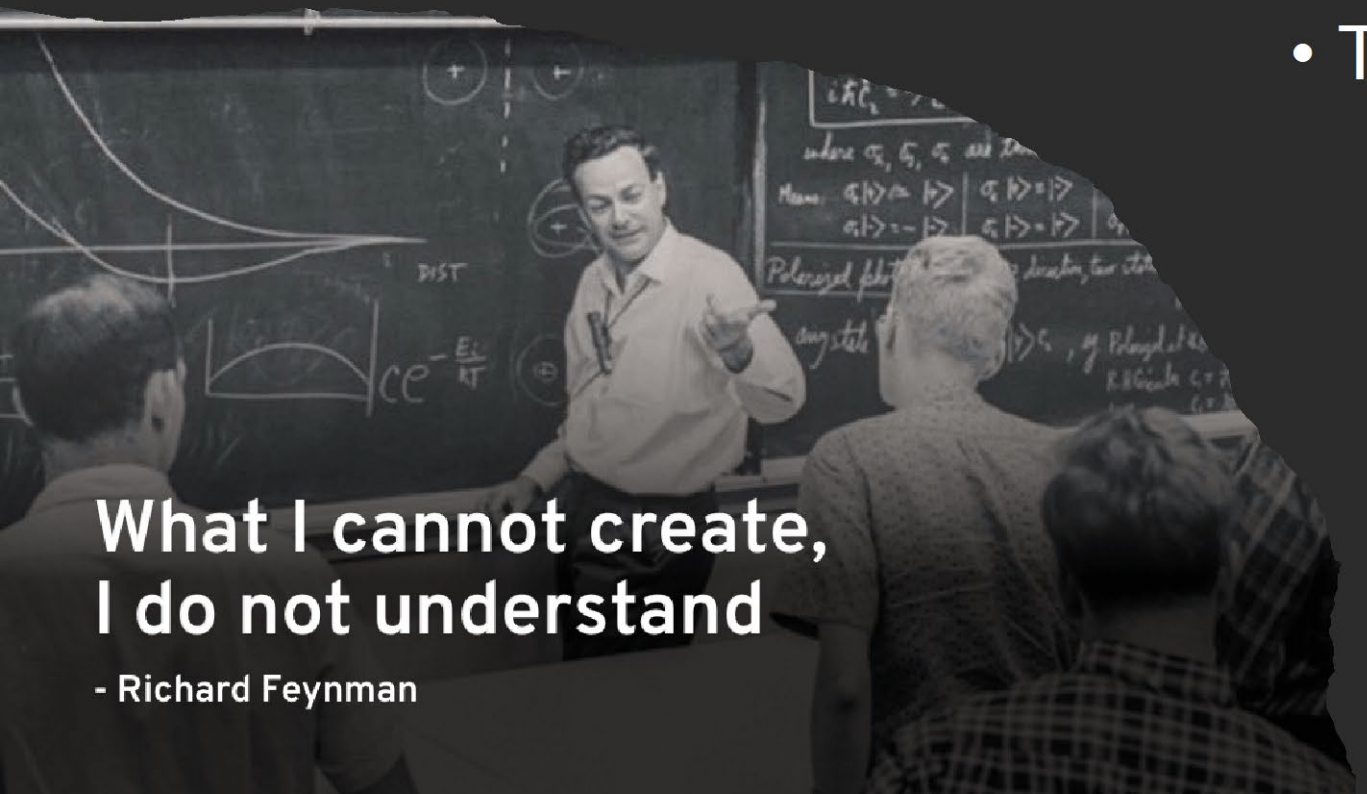
Discriminative AI estimates $P(Y|X = x)$, regression/classification models

Generative AI estimates $P(X)$ or $P(X, Y)$



Generative AI's Powerful Capability **Summarized**

e.g., "InnoVAE: Generative AI for Patents, Innovation, Firms"



- Learn to generate any complex object (e.g., images, documents, patents, jobs, firms, portfolios, consumers, digital twin of anything)
- Doing so, learns object space and compositions in scale
- Trained model can then:
  1. Map out the object space and provide deeper insights (compare & contrast)
  2. Augment purposeful synthesis of a new and creative object
  3. Do 1 and 2 at incredible scale and speed

How is Current Gen AI Lacking?

- **Polanyi's paradox:** human knowledge of how the world functions and of our own capability are largely beyond our explicit understanding. *Tacit Knowledge*
- Gen AI learns from web or available data
- **Lacking data on**: senses, muscle memory, *high resolution* of feelings and emotions. Anything we cannot explicitly state due to Polanyi’s paradox.
- **When will this be overcome? Who knows?**

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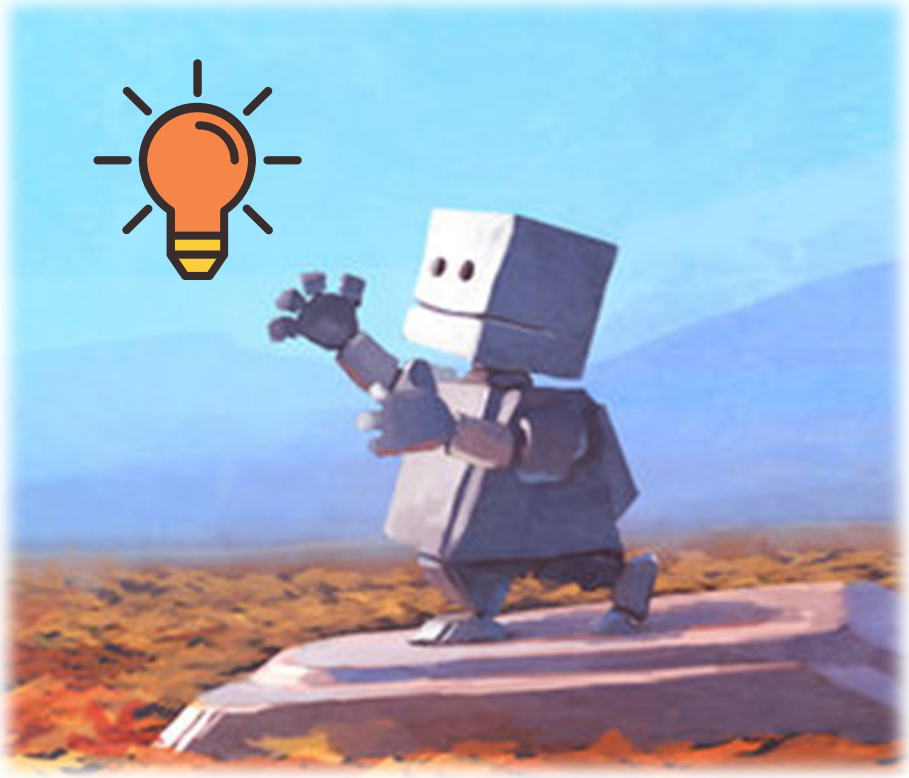


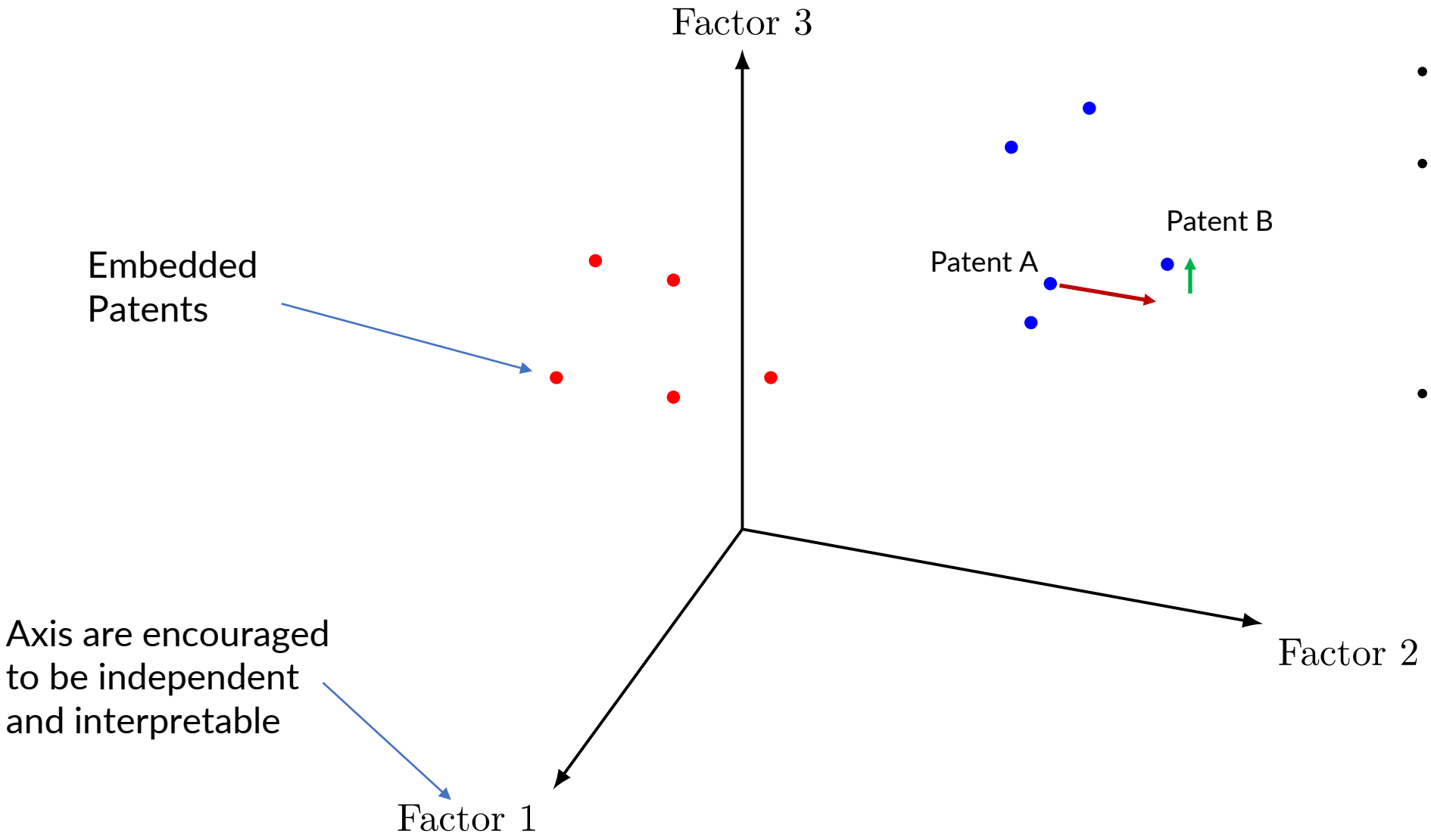
Research Question:
Can AI Represent Innovation? And how is this useful?

1. InnoVAE (variational autoencoder) to estimate disentangled representations of **patents** using multimodal data
   - map **real-world objects** → low dimensional vector space
   - (disentangling) each dimensions extracted such that:
     - Statistically more independent (semantically more orthogonal)
     - Movement within the space rendered meaningful/understandable
2. Patents in an interpretable vector space of factors of innovation.
   - e.g., Computing patents may reside in dimensions like “security”, “human-computer interaction”

Results & Contributions Overview

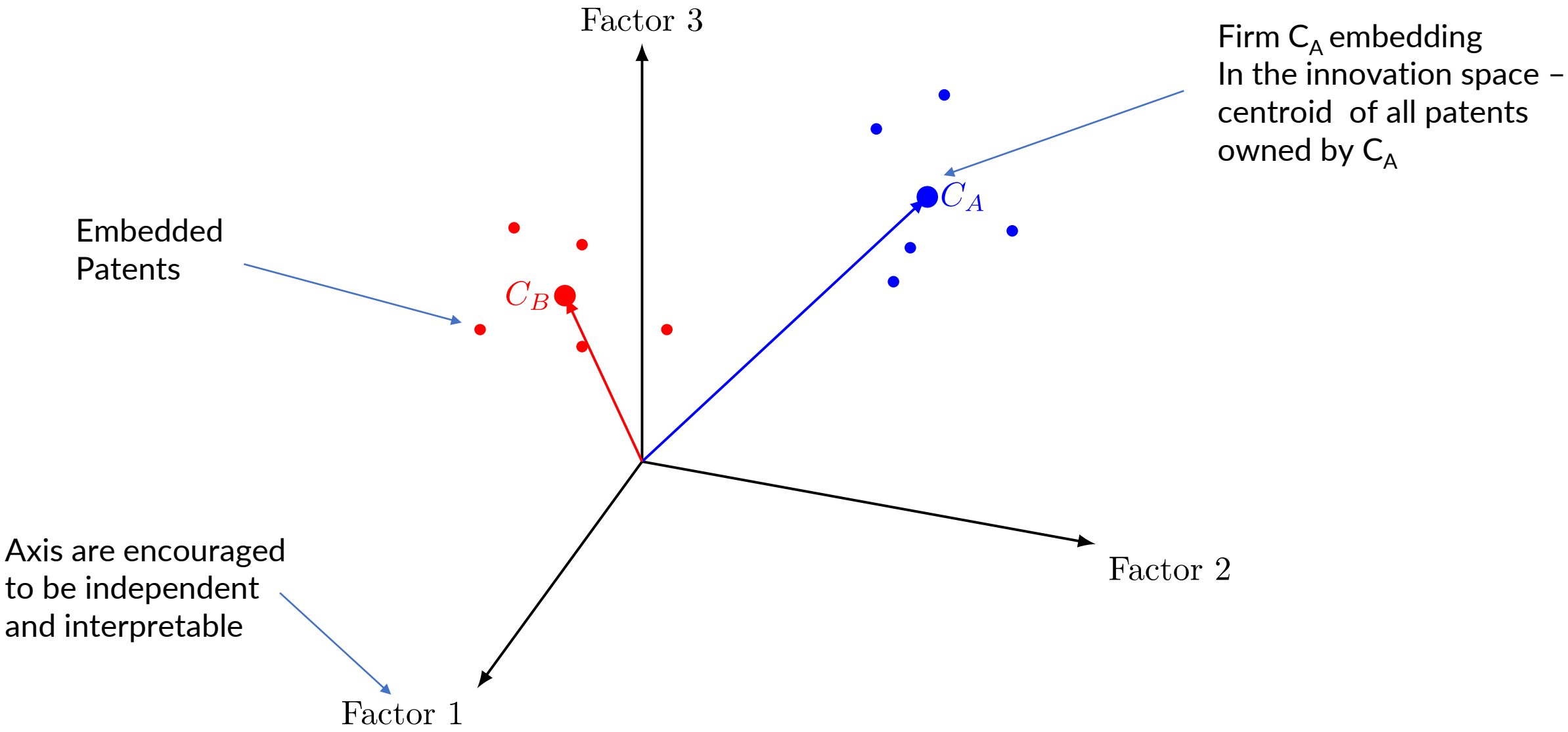
- **Innovation Space (IS)** – enable explorations into patents, innovation, and firms (providing distances and movement measures).
- **This approach can be used on any business objects (i.e., jobs, firms, products)**

Visualization of Innovation Space from InnoVAE

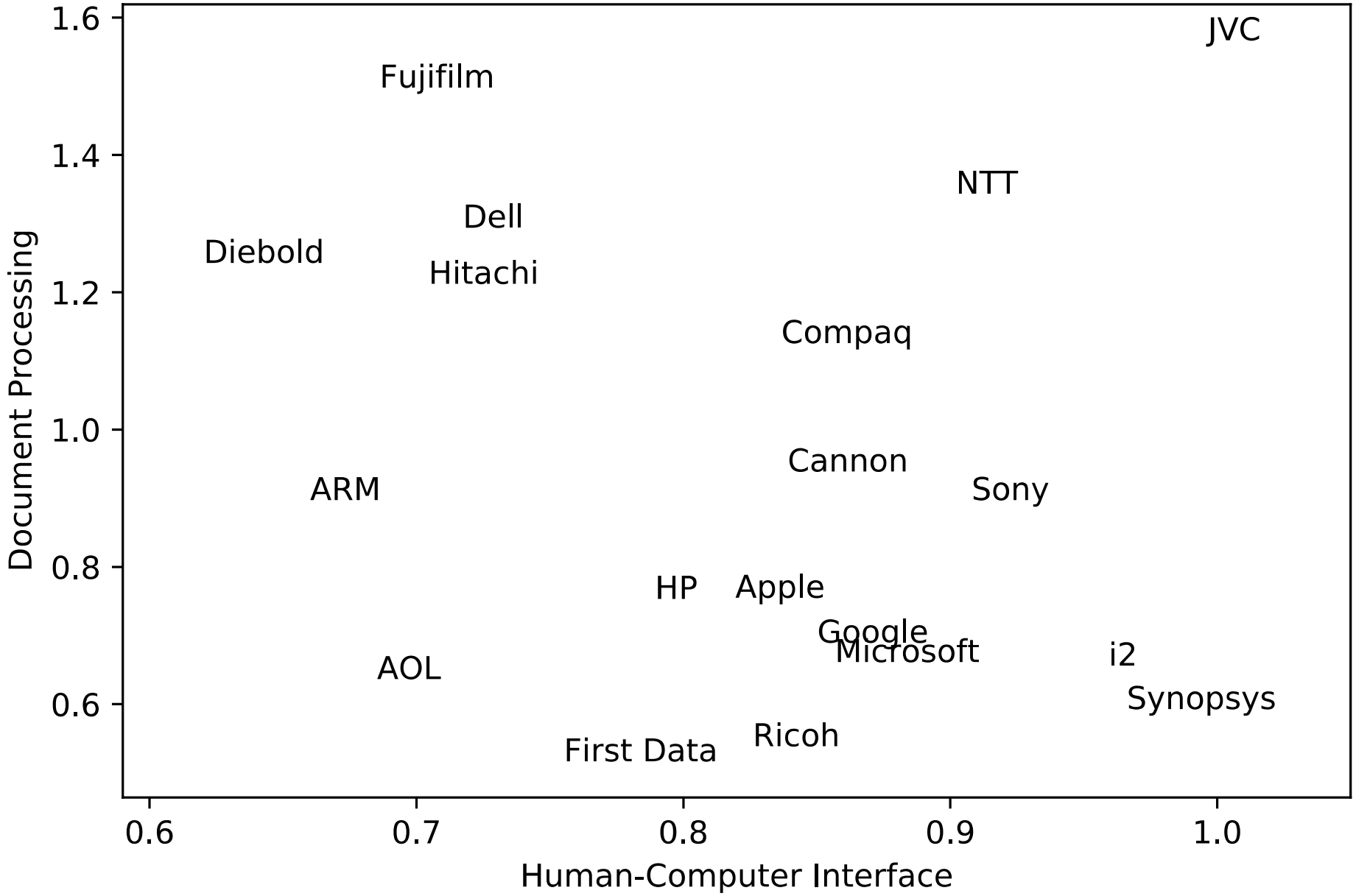


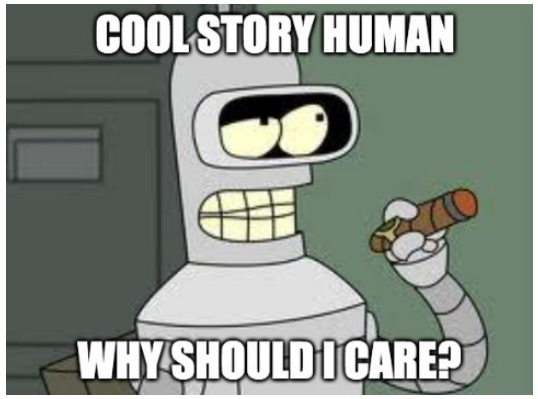
- Factors are distinct & Data-driven
- Similar patents are near each other
- Directions **are meaningful.** Patent B has increased factors 2 and 3 compared to patent A (i.e., more exceptional)
- **Not possible** with other visualization and mapping methods (e.g., PCA, t-SNE, Topic Models, traditional Autoencoders) – lacks **interpretability** and/or **orthogonality constraints**

Visualization of Innovation Space from InnoVAE



Situating Firms in the Innovation Space (2D Example)





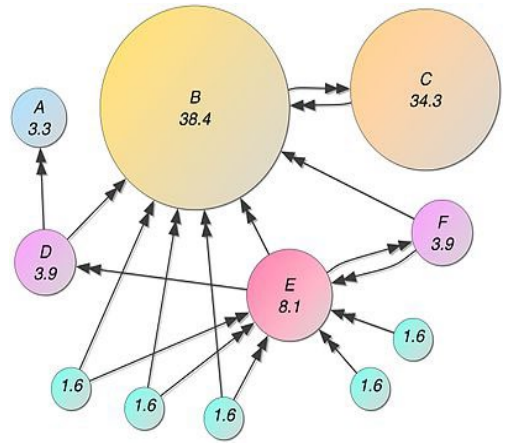
Good disentangled representation (Innovation Space) enables researchers to ask and explore:

1. What could you get if you combine patent A and B? (automate combinational creativity)
2. How exceptional (unusual) is a patent (e.g., iPod related) with respect to specific technological factor (e.g., user-interface)?
3. What innovation factors inc/dec over time?
4. Rank companies in technological factor X
5. If I am firm A, what innovation do I need to boost up to be more like Firm B?
6. How do firms move in Innovation Space over time and how does that correlate to some performance?
7. What happens to innovation activity in specific technological region after event X (i.e., acquisition, mergers)
8. etc

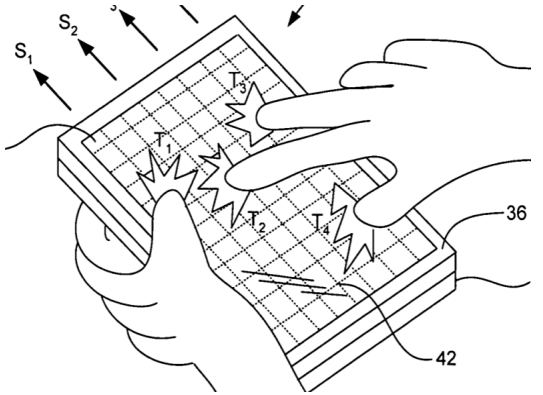
Data Context

US patent under “G06”

- Patents on computing systems
- 240K patents between 1980 to 2010



PageRank
by Google
(US# 6285999)



Multipoint
Touch
by Apple
(US# 7663607)

Examples of patents under G06 group

Example Innovation Factors (Disentangled Axis)

Semantic structure of latent space (Patent Fusion)

$$\mathbf{z}^{(\text{fused})} = \mathbf{z}^{(a)} + \mathbf{z}^{(b)}$$

#5873080 Using multiple search engines to search multimedia data

#7689506 System and method for rapid updating of credit information

$\mathbf{z}^{(a)}$

$\mathbf{z}^{(b)}$

#5162638 Process for protection against fraudulent use of smart cards, and device for use of the process

$\mathbf{z}^{(\text{fused})}$

Patent Level Exploration

Ranking Overall Exceptionality of Patents

Guiding Theory: Margaret Boden Creativity Concept + Geraint A Wiggins' Formalization of Creativity

Creativity Ranking Via "Conceptual Space" – "Universe of Thoughts"

- For human, it's the structured way of thoughts with frameworks, rules, and, constraints. E.g., sonnets, game of Go
- For machine, it's an algorithmically-defined representation space easily understood as embedding vector space (i.e., space with constraints and directional meanings).

Three levels of creativity

- **Combinational**: obvious combination of extant ideas within a conceptual space
- **Exploratory**: exploration within a conceptual space beyond simple combination
- **Transformational**: beyond the boundary of a conceptual space

(Exploratory + Transformational are jointly referred to as "Impossibilist")

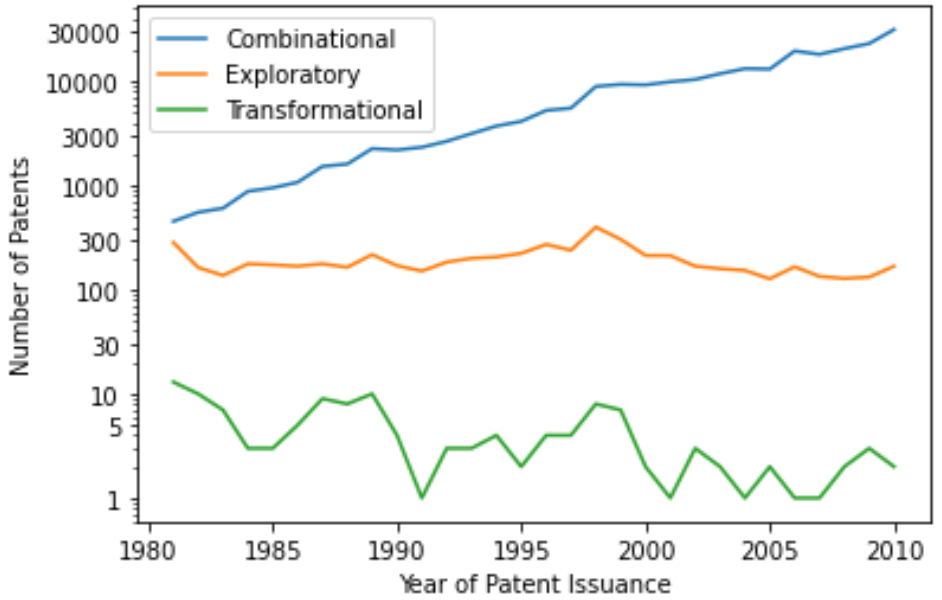
Descriptive comparison of different innovation types

Combination innovations (CI) experience **stable exponential growth**

Impossibilist innovations (EI + TI) created *per annum* **remain steady** over the years

Creative ideas get relatively more scarce

- In 1980s, every ~3.6 CI come with one EI or TI
- In 2010, every ~200 CI for one EI or TI



Number of G06 patents issued per year (in log scale)

Firm Level Exploration

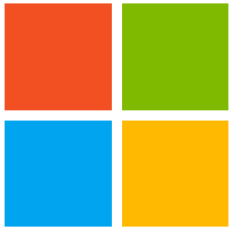
Characterizing Firms by Their Patents

Innovation Factor & Top Ranking Firms (G06, 1980-2010)

Technological Factor i	Most Innovative Firms	Firm's Main Business Line	Innovation Index δ_i
Human-Computer Interaction	Nintendo	Video game	2.0781
	Pixar	Computer animation	1.6756
	Immerson	Haptic technology	1.6254
Automation / Control	Intertrust	Digital rights management	1.6756
	Silicon Motion	Hardware	1.6254
	Toyota	Automobile	1.2582
Finance / Transaction	VISA	Finance	2.3951
	CME	Exchange	1.3542
	Salesforce	Customer relationship management	1.2225
Connectivity	Wells Fargo	Finance	1.1004
	West Corp.	Telecommunication	1.0803
	CommVault	Data management	1.0668
Document processing	Fuji	Document solutions	1.4982
	NTT	Telecommunications	1.3436
	Dell	Computer products	1.2941

Firm & Their Synthetic **Representative Patent Abstract**

a system for transfer fund between a sender and a recipient, include a sender and a receiver, each of which be associate with a sender the secure system (10) include a secure electronic document (20) , a secure document (24) , and a secure document (28)



a portable computer system have a screen and a keyboard for use with a computer system. the main body have a display portion and a display portion. the keyboard have a plurality of key, each of which be associate with a key of the keyboard. the keyboard be arrange in a manner that be transparent to the user

a method for provide a user interface for a computer system have a plurality of computer system, each of which be capable of communicate with a computer system. the device be connect to the display device via a communication link. the method include the step of: (a) receive a plurality of control signal from the computer system; (b) receive a signal from the computer system, and (c) transmit the control signal to the computer system.

Firm & Their Synthetic **Representative Patent Abstract**

a portable computer have a housing and a display screen. portable electronic device have a display screen for display information. the display device be mount on the display device and be configure to be removably attach to the display device.

A method for control the operation of a printer, such as a printer include the step of: (a) receive a print command from a host computer; (b) receive a command from the host computer to print the command.

a method for control the operation of a motor vehicle. the method include the step of : (a) determine a current flow of the motor vehicle; (b) determine a current flow of the motor vehicle.

Table 8: Technology gaps between incumbent and entrant firms

Incumbent	Entrant	Factors of Technology Gap
Toyota	Google	Automation (0.599), Manufacture (0.315), Security (0.155)
	Apple	Automation (0.526), Manufacture (0.264), Connectivity (0.200)
Honda	Google	Information retrieval (0.183), Security (0.171), Ergonomics (0.160)
	Apple	Ergonomics (0.213), Connectivity (1.89), Information retrieval (0.126)
Ford	Google	Security (0.233), Hardware (0.227), Automation (0.179)
	Apple	Connectivity (0.203), Security(0.173), Ergonomics (0.149)

(a) Automobile market

Incumbent	Entrant	Top Factors of Technology Gap
Siemens Health	Google	Ergonomics (0.134), Manufacture (0.129), Hardware (0.127)
	Apple	Connectivity (0.195), Ergonomics (0.187), Medical diagnosis (0.110)
Medtronic	Google	Hardware (0.307), Medical diagnosis (0.220), Security (0.113)
	Apple	Medical diagnosis (0.230), Hardware (0.125), Connectivity (0.124)
GE Health	Google	Hardware (0.132), Connectivity (0.094), Manufacture (0.082)
	Apple	Connectivity (0.175), HCI (0.036), Manufacture (0.032)

(b) Healthcare market

Companies have been using UGC/Reviews to Design Products

The Amazon Whisperer

On the trail of a mysterious online company that has cracked the secret to making products people want.

Albeit... Mostly Manually

C & A Marketing

"Entire team of people who read reviews on Amazon, looking for moments when people say, *I wish this speaker were rechargeable.*"

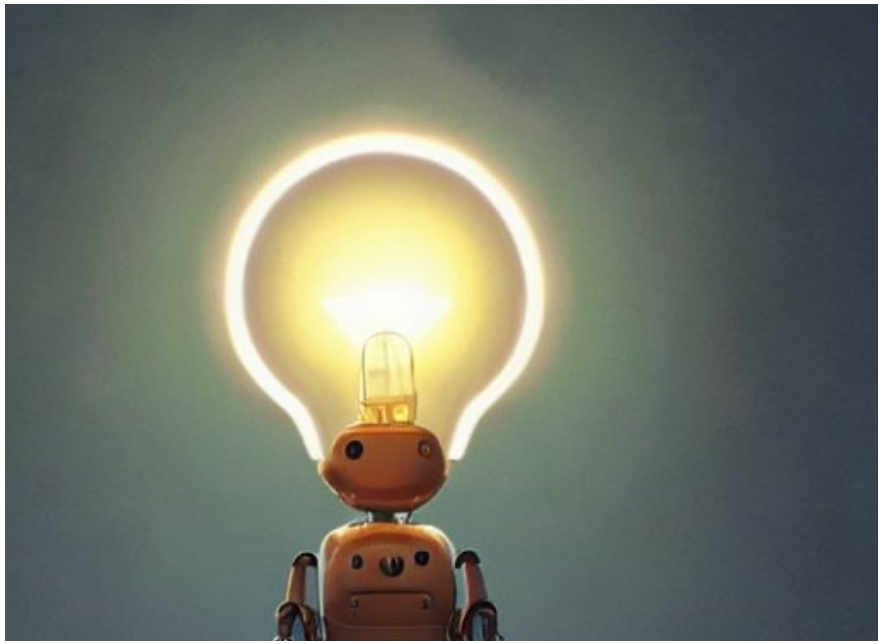
Then they make it.

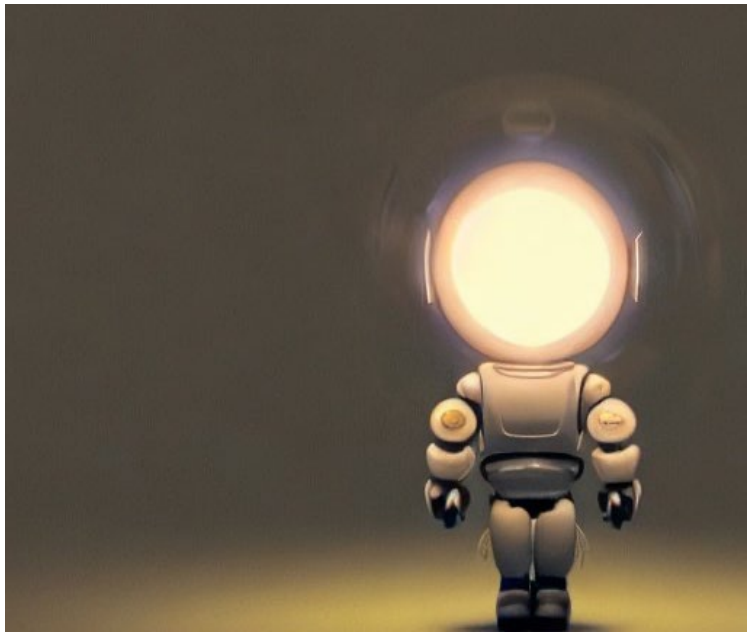
Why Not

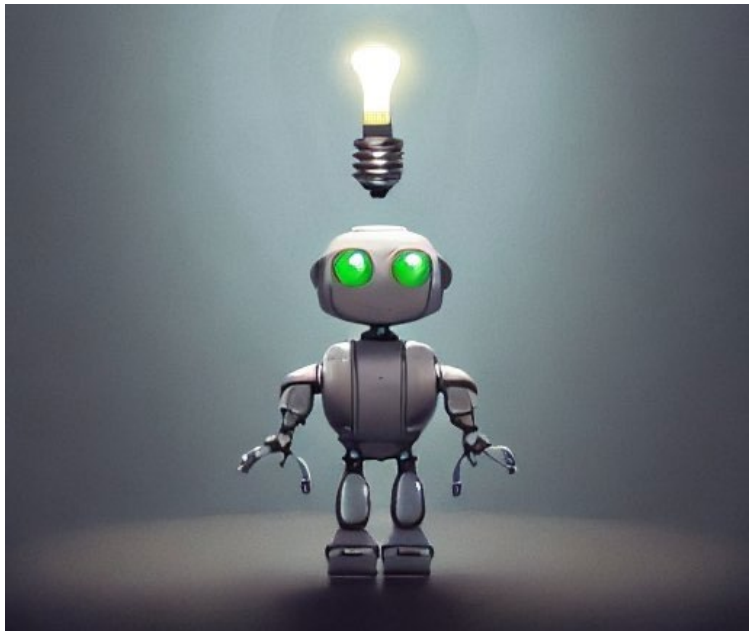
- **Products** in Feature Spaces (Customer Reviews)
- **Products** in Wish-Feature Spaces (Customer Feedback, Complaints)
- **Brands** in Personality Spaces (Social Media Data)
- **Assets** in Risk Spaces (10K, earnings report, analyst report)
- **Jobs** in Skill Spaces (Job Description Data)
- **Firms** in Business Strategy Spaces (Pitchbook, 10K, etc)
- Etc…

Takeaways

- InnoVAE is an **exploratory tool**
- This approach enables interpretation, comparison, visualization, and augmented creation.
- **New possibilities brought by generative approaches in business!**







Thank you!
Feedbacks and Comments are Appreciated

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