

Generative Intelligence Techniques in Industrial Product Design

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Abstract

The present study, investigated generative intelligence design techniques. Generative design employs specialized software developed from the advancement of artificial intelligence programs, utilizing the computer as an enabling tool. This tool is used alongside the designer's scientific expertise to guide models based on input criteria, thereby enriching the design of shapes. These applications significantly contribute to industrial design by reducing time and cost. To illustrate this, the researcher conducted experiments using the Midjourney generative intelligence design program, demonstrating its capability to generate products with logical descriptions within industrial design contexts.

Keywords: Technology, Generative Intelligence, Industrial Product.

INTRODUCTION

Research Problem

Generative intelligence represents a sophisticated approach to the design of machines, offering an effective resource for the design process. The advent of new technologies related to generative intelligence has led to significant advancements in design during the current century. This progress is attributed to the development of numerous applications that have enhanced and innovatively shaped designs, making substantial contributions to industrial product design by maximizing efficiency and unique aesthetic value. These applications have continually evolved, enabling precise design processes and reducing the time and effort required. This is achieved by relying on criteria input by the designer, which dictate the nature and elements of the product. To explore this, the researcher conducted experiments using the Midjourney Generative Intelligence Design Program. Consequently, it became necessary to research and study this phenomenon by posing the following question: Can generative intelligence be effectively controlled to design industrial products with logical descriptions within industrial design contexts?

Research Significance

The significance of this research is centered on the following:

The research underscores the role of generative intelligence in the design of industrial products and its critical importance.

It elucidates the crucial role of the designer when utilizing generative intelligence design applications.

Research Objectives

The current research aims to:

Explore the potential of generative intelligence in generating models of industrial products through practical application using Midjourney.

Codify the commands that can be given to artificial intelligence to achieve optimal design results.

Definition of Terms

Generative Intelligence: Generative intelligence is a branch of artificial intelligence that focuses on automatically creating new and innovative content rather than merely analyzing or using existing data. This

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form of AI can generate various types of content, such as texts, images, and sounds, that mimic human creativity (Al Khalifa, 2023, p. 6).

Generative Design: Generative design is an algorithmic process that employs rules, known as "genes," to systematically create a range of diverse potential design solutions (Fasoulaki, 2008, p. 10). This approach transforms computational power into a creative exploratory tool, allowing human designers to investigate numerous design possibilities within adjustable parameters (Adeeb, 2017, p. 36).

LITERATURE REVIEW

Generative Intelligence Applications:

Generative intelligence design is a result of significant advancements in the AI subfield of machine learning, which has already impacted numerous areas of life (Beckler, 2021). The first modern model for converting text to images was alignDRAW. Although the initial images produced by alignDRAW were blurry, they demonstrated the model's ability to generate unique content without saving existing data (Mansimov, Lee, & Salahudinov, 2015, p. 30). Applications of generative intelligence have continued to evolve, with Midjourney emerging as a prominent example that achieves advanced results. Other notable applications include ChatGPT and DALL-E, which are AI systems that generate text and images, respectively. These applications have gained substantial potential due to recent developments and the extensive datasets utilized in their training.

ChatGPT (GPT-4): ChatGPT is a mathematical model that uses probabilities to understand textual context and predict relationships between words. GPT stands for Generative Pre-Trained Transformers, indicating its capability to generate new content. It is pre-trained on a vast dataset, allowing it to continue learning and acquiring new data through interactions with humans (Gomez, Kaiser, & Polosukhin, 2017, p. 21). This specific type of deep learning neural network is particularly effective in language learning, as AI models convert text into images using extensive datasets with captions.

DALL-E 2: The DALL-E 2 generation system, developed by OpenAI, is based on the provided data. This system, whose complete computer code is available for public use (Cope & Nieminen, 2023, p. 86), relies on remixing and reintegrating existing standards related to vector learning models. In DALL-E 2, the relationships between words or between words and images are predicted, enabling the generation of the most likely combinations of words or images (Florida, 2023, p. 36).

Midjourney

Midjourney is a distinguished generative intelligence program designed to generate industrial products. It utilizes a comprehensive database to define and depict vocabulary and respond to criteria specified by the designer. The program generates images as models of the intended designs, addressing design challenges by providing a wide range of signals and options. Midjourney's capability to produce environmentally acceptable shapes within the designer's parameters is achieved through specific scientific methods (Turrin, Von Buelow, & Stouffs, 2011, p. 25). The researcher has used Midjourney in a practical experiment to generate shapes for industrial products, detailed as follows:

After downloading Midjourney from Google, users enter the program interface, which presents various options. Without a special Discord account, users choose the "join Beta" option to access a group of servers. By selecting a server, users' designs appear on the main page alongside other designers' works. New users can join "newbies" servers, where hundreds of designers might be working simultaneously. Designs are rendered and distinguished by an orange shade. Subscribing via email and creating a private page allows users to freely communicate with the bot and save designs with descriptions. Existing Discord users can access a personal page and navigate the program options to generate the desired product designs, utilizing up to 20 image repetitions to achieve the appropriate design.

Industrial Product Design Standards in Midjourney

The process of establishing design standards for generative intelligence applications involves managing the information fed into the programs, which supports the form, function, and performance required throughout the product's life cycle. This approach considers material characteristics, influencing forces, and variables that enhance the optimal function and performance of the product, alongside form design. Variables in material size and distribution ensure quality, such as weight reduction, achieved more efficiently through design practices that use algorithms to rapidly explore numerous design possibilities or improvements. This leads to designs that appear organic and representative of natural forms (Monizza et al., 2018).

By organizing the initial design inputs specified by the designer, key points are created through constraints imposed by the program. These points represent the main fixed inputs, determining the forces acting on each initial design point and providing the program with the necessary information to evaluate the distribution of standards and their paths. The program then generates iterations of the designs based on the improvement goals (Oh et al., 2019), as demonstrated in the researcher's experience with the Midjourney program. The process involved entering the standards into the program as inputs to obtain the desired product or design.

To input design standards or descriptions in Midjourney, users start by entering the chat bar. The first step is to click on the "imagine/explain" option. If the explanation option is not available, users must manually write it, which means "imagine." Initially, the program will request approval of its terms, which must be granted before beginning the design process. After agreeing to the program's terms, the design process begins in Midjourney. At this stage, the design elements are specified, including the required materials, colors, textures, and sizes, either by writing them directly or by supporting them in a manner akin to the desired design. Midjourney integrates closely with the designer to ensure success through data transfer and sharing within a program environment (Isikdag & Jarrah, n.d.). This optimization process depends on materials and constraints integrated with analysis and generative design applications. Inputs are entered as follows:

Standards are written exclusively in English. Before writing the standards, we must understand that the Midjourney program has multiple versions. If we write standards directly without specifying the version, the bot will use the first version. As of 2023, the fifth version is available. Without specifying the version, the bot generates designs that appear as drawings or oil paintings, lacking accuracy. For realistic and high-accuracy images, write "imagine/".

After writing the standards, specify the version, for example, the fifth version, by writing "v5". To make the image appear realistic and accurate, include precise details and symbols like "4k" or "8k". The bot needs symbols and signals to access minute details.

Click "Imagine Start" and wait for the program to generate the desired shape or design based on the criteria. The program will generate images or designs from which we choose the best and most accurate.

If the designer wants to rewrite the standards, new shapes will be generated that differ from the previous ones. This step is common to all generative intelligence programs. Options under the image allow for modifying the design, giving the designer control over the design through these modifications.

The program allows chatting with other designers and publishing the design on the main page for visibility. Designers can communicate directly and interact using symbols like the heart, chat, and ask questions. The program also enables generation on a special page.

Steps on How to Work with Midjourney

Write a Description of the Design or Requirements: Clearly describe the design or specify the requirements for the project.

Specify the Style or Artist: Indicate the name of the style or artist whose style you want to emulate. Midjourney has a special library listing the styles of various artists whose symbols can be used, or you can use the designer's unique style.

Include Semantic Words: Add semantic words to the design description to reflect the desired outcome. The standards should also include information and variables about the product's function and purpose.

Different standards can be created with varying variables. A set of standards must be described to evaluate the design results against the optimal values for form and function.



Figure (4): The researcher's design for a central table using Midjourney.

Suitability in Generative Design

Suitability in generative design is achieved by adjusting the input data, which represents the standards, to either increase or decrease the complexity. This involves choosing inputs characterized by simplicity to facilitate data readability and achieve an integrated construction process. By expanding the scope of the generated samples, designers can better align with their expectations for the intended outputs.

As illustrated in Figure (4), which shows the researcher's design for a central table using the Midjourney program, the generative act is synthetic and requires an integration of generative and evaluative capabilities. This process relies on characteristics that support shape generation, analytical evaluation of functional performance, and environmental adaptation by simulating natural conditions (Takenaka & Okabe, 2013, p. 289).

These features represent the key standards provided by the designer as inputs to generative design programs. These programs build superior systems capable of continuous development, creating intelligent systems that emulate, and sometimes exceed, human design processes. They use analytical principles and branching, tree-like information structures to generate plans for qualitative alternatives (Turrin, Von Buelow, & Stouffs, 2011, p. 25). The Midjourney program contains numerous options that align with traditional standards in design work.

Basic Design Elements in Midjourney

The Midjourney program contains a database and an integrated basis for the fundamental elements of design: material, texture, and colors. Each element offers various options, which the researcher will detail as listed in the program.

Material: Material is a crucial criterion chosen and approved by the designer as a fundamental element of product design, alongside other elements that work together to produce the product's final appearance. The Midjourney program includes a variety of material options. The researcher will detail these options in the following table.

Table (1) Raw material options on Midjourney, prepared by the researcher

<p>Ceramic Porcelain earthenware stoneware Bone china Glazed ceramic</p> <p>Uncoated cera</p> <p>Textiles cotton wool Silk Linen leather Synthetic fabrics mic</p>	<p>Wood oak Maple Cherry Mahogany walnut ash Pine glass</p> <p>Transparent glass stained glass Solid glass Laminated glass stained glass Etched glass</p>	<p>Raw materials Metals Aluminium steel copper copper Nickel Titanium stainless steel Plastic Thermoplastic polyurethane (TPU) Polypropylene (PP) Polyethylene (PE) Polystyrene (PS) Acrylonitrile butadiene styrene(ABS) Thermoplastic Elastomers (TPE) Polycarbonate (PC)</p>
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Texture: No shape can exist without a surface texture characterized by certain properties, such as smoothness or roughness. Form and texture are inseparable in their smoothness, and texture holds significant expressive and functional meanings for the product, reflecting the relationship between visual and tactile sensations. The Midjourney program offers a range of textures for designers to use, detailed by the researcher in table 2 below according to the program's classification.

Table (2) Texture options on Midjourney, prepared by the researcher

<p>Abstract texture Organic: swirls, waves, clouds, flames Geometric: grids, honeycombs, fractals, mandalas Crocodile skin texture</p>	<p>Visual texture Patterns: stripes, checks, polka dots, paisley Lines: straight, curved, diagonal, zigzag Shapes: circles, squares, triangles, stars</p>	<p>Real texture Wood: smooth, rough, knotty, grain Metal: shiny, matte, polished, rusty Fabric: smooth, rough, soft, hard Paper: smooth, rough, glossy, matte</p>
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Engravings: Engravings provided by the Midjourney program offer formal arrangements that impart distinct characteristics to products, aiding in differentiation and adding aesthetic value as determined by the designer. The program includes a base of engraving options for designers to choose from, which the researcher has documented. which are detailed in the table 3 below:

Table (3) Engraving Options on Midjourney, Prepared by the Researcher

Leopard Print	Herringbone	he moved
SCROLL	Greek	Pink
FLORAL	Clover	Strips
STRIPES	Argyle	Giraffe print
Giraffe Print	Diamond Link	Tiger print
Tiger Print	Swirls	Dotted
POLKA DOT	Suns	geometric
ZEBRA	Hippie	Cow print
GEOMETRIC	Hearts	Snake print
Cow Print	Fleur de Lis	Standards
Snake Print	Anchor	Chevron
SCALES	Feathers	Tests
CHEVRON	Honeycomb	Crocodile Chevron
CHECKS	Arrow	High Chevron
Crocodile Print	Ikat	Polka Dot
Jester	Maze	Preppy Dot
Chic	Houndstooth	Linked
Retro	Cross	Vertical Stripes
Crocodile chevron	Zebra	Circles
Wood	Elephants	Roses
Marble	Paw Prints	Squares
	Aztec	Escape
	Stars	Horizontal Stripes
		print

Color: In the field of generative design, color plays a significantly influential role in highlighting contrasts within the elements of form design. The contrast of colors affects the response process and perception, as well as the incentives, influences, and stimuli that vary according to the colors and their connotations (Kalash, 1996, p. 116).

Colors are considered one of the most important aesthetic elements affecting product design and have a significant psychological impact, as each color carries specific connotations. Design uses color to achieve the formal appeal of products by attracting attention. When a designer effectively uses the color wheel and understands the shades of each color, it fundamentally enhances the design work, achieving visual perception and engaging the recipient's visual sense (Beveridge, Domenech, & Pascual, 2003). Therefore, designers play a crucial role in effectively communicating with generative design programs, making informed choices based on the scientific principles of design (table 4).

Table (4) Color Options on Midjourney, Prepared by the Researcher

YELLOW Green	Blue	Violet	Red	Orange	Yellow
App/s	Azure	Amethyst	Barn	Apricot	Blond
Army	Baby	Amethyst	Beet	Burnt Orange	Buff
Avocado	Blueberry	Black Raspberry	Blood	Burnt Sienna	Butter
Celery	Bluebonnet	Concord	Blush	Cadmium	Canary
Chartreuse	Celestial	Damson	Bordeaux	Carrot	Chamois
Citrine	Cerulean	Eminence	Bubble Gum	Copper	Chamois
Fern	Cobalt	Grape	Burgundy	Red Orange	Corn
Lemon-lime	Cornflower	Lavender	'Cardinal	Bittersweet	Cream
Lime	Delft	Purple	Carnation	Bittersweet	Daffodil
Moss	Denim	Royal Purple	Carnation	Papaya	Dandelion
Neon	Iceberg	Blu Violet	Cayenne	Persimmon	Flax
Olive	Indigo	Bluebell	Cherry	Pumpkin	Gold
Pea	Lapts	Eggplant	Chinese	Rust	Goldenrod
Sage	Liberty	IRIS	Claret	Salmon	Grapefruit
Dark gray	Midnight	Periwinkle	Rose	Red Violet	Honey
Silver	Navy	Purple Heather	Cotton Candy	African Violet	Jasmine
white	Phthalo	Blue Green	Cotton Candy	Boysenberry	Jonquil
washi	Powder	Aqua	Cranberry	Violet	Lemon
rosy	Prussian	Aquamarine	Crimson	Byzantine	Yellow Orange
	Royal	Azure Mist	Fire Engine	Heliotrope	Amber
	Sapphire	Bottle	Fire Engine	Fuchsia	Bisque
	Ultramarine	Cadet	Flamingo Pink	Magenta	Butterscotch
	Winsor	Cyan	Garnet	Mauve	Cantaloupe
	Green Celadon	Peacock	Maraschino	Mulberry	Caramel
	Emerald	Persian	Pink	Orchid	Cheddar
	Forest	Pine	Raspberry	Plum	Gamboge
	Grass	Robin Egg	Ruby	Puce	Mango
	Hunter	Sea	Scarlet	Purpureus	Naples
	Jade	Sky	Strawberry	Thistle	Ochre
	Jungle	Teal	T'ea Rose		Peach
	Kelly	TopaZ	Tomato		Safety
	Laurel	Turquoise			Saffron
	Locen	Viridian			brown

Submit a Photo

Providing an illustrative image of the shape to be designed is one of the options that the Midjourney program offers to help the designer confirm the product to be generated. The dimensions and size of the image also assist in determining the required size of the product. Additionally, semantic words such as "lighting look" are used to specify the type of camera lens or style. For instance, writing "35mm" indicates the type of camera lens, while "fog" suggests a blurry image style. Including terms like "cinematic" in the description indicates a desire for the shape to appear more accurate, realistic, and detailed.

Steps to Specify the Image as a Model in Midjourney

Determine Image Size and Format: Specify the image size using a rectangular aspect ratio such as 3:3 or 2:3. Include other types if necessary. For specific models, include the year. For example, write "S1800" followed by "style" for the program to recognize.

Include High-Resolution Detail: Write "8k" after the version type to ensure high-resolution detail.

Use Famous References: Utilize famous words, signs, movie names, or other well-known references, not just artist styles, to guide the design.

Modify Existing Designs: Modify designs or images downloaded from the web or your computer. Use the "imagine/" command followed by your description and modifications.

Use Web Images: If using an image from a website, right-click on the image, open it in a new tab, copy the link, and then paste the link in Discord after "imagine/".

Quality Standards: Image quality depends on generation type, version type, and the "virgin version" type, written as: --v1, --v2, --v3, --v4, --v5

Standard Image Sizes: Specify standard image sizes: 1:1, 4:7, 2:3, 4:5, 5:4, 2:2, 7:4, 3:2 If not specified, the program defaults to a 2:2 scale.

Image Resolution Standards: Image accuracy and clarity depend on:

Type of version

Type of model

Type of camera lens

Use commands in the program's control settings to adjust these factors.

Selection Criteria

Choose a presentation style using commands. For example, write "s" followed by the artist's name to specify an artist's style.

For a specific designer, write the designer's name or the style's name.

To indicate a time period or style, include the year (e.g., "1956" for a vintage style).

Lighting Standards:

Specify lighting conditions:

Daylighting: Use terms like "sunny mood," "sunny window."

Night mood: Use terms like "night mood."

You can add modifications to the design or delete specific parts of the design as needed.

By following these steps, you can create high-quality images and designs, ensuring the desired style and accuracy.

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Practical Aspect of Research: Analysis of the Experimental Designed Models

Prototype 1



Type	Material	Color	Engravings	Texture
Description of the children's dental chair image	sustainable wood	Pink	without	GEOMETRIC
	nano-illumination	purple		
		Blue Green		
		white		

Design standards Provided to Midjourney:

The researcher provided Midjourney with standards that include the essential features needed for a pediatric dentist chair. These features ensure the chair's performance and adaptability for children of various sizes:

Adjustable Height: The chair's height can be modified to suit children of different sizes.

Adjustable Backrest: The backrest can be adjusted to a comfortable position for the child.

Footrests: Footrests can be raised or lowered to support the child's legs.

Armrests: Armrests provide additional support and comfort for the child.

Head Pillow: An adjustable head pillow supports the child's head and neck.

Seat Belt: A seat belt ensures the child's safety in the chair.

Entertainment Features: The chair includes fun design features like a built-in television or screen to distract the child during procedures and a sound system to play music or other sounds to help the child relax.

Functional Additions: Tools and equipment, such as a mechanical power source, handpieces for dental procedures (drilling, polishing, cleaning), and a device to spray water, air, or an anesthetic solution, were integrated to make the design comprehensive.

Ergonomics: To achieve a realistic performance based on scientifically studied foundations, the researcher provided comfortable measurements for children's bodies and supportive seats with a backrest suitable for their age.

Size: The researcher defined the unit's dimensions to ensure the child's comfort and ease of movement, considering the appropriate size for side tools.


Sustainability: The researcher prioritized using environmentally friendly materials that are non-toxic and offered options for dismantling the unit and recycling its components after their lifecycle ends.

Model Generation and Analysis

Generative Intelligence Techniques in Industrial Product Design

On 2/21/2024, the Midjourney program was accessed to survey the channels, totaling 172 channels. From these, 19 industrial design-related models were identified, and 10 main models were selected using systematic keywords. The results are summarized in the following table:

Engravings	Texture	Material	Color	Design type	Design
wood		Wood	purple accents	First aid supplies box	
			red and blue	Nike shoes inspired by a notched potato chip	
		Plastic	pink	Portable fan	
wood		Plastic wood	black	sophisticated electric coffee	
Crocodile print	Crocodile skin texture	Crocodile Leather	brown	Traditional Australian Crocodile Leather Accessories	
		wood	brown	Various pieces of furniture	
		wood	washi brown	Kitchen	
marble pattern	smooth	wood walnut	light brown and bronze	modern kitchen	
			dark gray and silver	Macaulay McDonald's Front Kitchen with Focus on Built-in Oven	

marble		leather	washi brown	micro size tote bag	
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We note from the previous table the criteria that were applied to Midjourney by the designers to generate the mentioned models. In comparison with the criteria previously extracted by the researcher, the following usage percentages for those criteria were identified as follows:

The percentage of using color compared to what was extracted was 6 percent.

The percentage of using material compared to what was extracted was 8 percent.

The percentage of using texture compared to what was extracted was 14 percent.

The percentage of using patterns compared to what was extracted was 4 percent.

RESULTS AND DISCUSSION

The model design process yielded several notable results:

Integration with Traditional Scientific Foundations: The models achieved logical descriptions within the design contexts on the Midjourney program. This was accomplished by integrating traditional scientific design foundations with the program’s capabilities to generate comprehensive shapes.

Balance Between Utility and Aesthetics: The models balanced utility and aesthetics by providing clear details of the general appearance. They achieved color harmony and size proportionality, thereby generating aesthetic values.

Emphasis on Sustainability: The models emphasized sustainability by proposing materials suggested by the researcher and using modern materials provided by the Midjourney program. These materials support sustainability and the use of natural raw materials. The designs also supported sustainability principles by allowing for the dismantling and recycling of products after their lifecycle.

Basic and Additional Design Features: The design treatments provided by the researcher to the Midjourney program ensured the inclusion of basic features as well as additional features, aligning with the program's ability to generate functionally and aesthetically integrated products.

Appropriate Use of Colors: The use of colors appropriate to nature enhanced the attractiveness of the models. The Midjourney program’s extensive database of colors and gradients provided a wide range of choices, adding to the aesthetic appeal.

Diverse Texture Options: The texture options supported by the Midjourney program allowed for greater diversity in texture, adding aesthetics to the designed models.

Potential of Generative Design: Generative design demonstrated significant potential in generating products with functional and aesthetic values and distinctive shapes, serving as an inexhaustible source of new forms.

Role of Human Creativity: Despite the capabilities of generative intelligence design programs, they cannot replace human intelligence. The designer’s experience, creativity, and innovative ideas are crucial. The designer's creativity and ideas, based on foundational and studied design treatments, are essential for designing industrial products with logical descriptions within industrial design contexts. Without these human elements, achieving the required functional performance and aesthetics is challenging.

Midjourney’s Ability to Evaluate Complex Inputs: The Midjourney application is distinguished by its ability to evaluate complex inputs, interpret them, and provide advanced models.

Subjectivity of Inputs: The inputs in the Midjourney program are not followed objectively, as evidenced by the small percentages observed in the theoretical framework.

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