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VISUALISING SPECULATIVE MATERIALS: USING TEXT-TO-IMAGE PROMPTING TO ELABORATE LIVINGNESS AS A DESIGNED MATERIAL QUALITY

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ABSTRACT
Generative AI (GAI) technologies have started to transform design processes through integration into various stages such as research, ideation, visualisation, and reporting. Designers use textual prompts to quickly incorporate AI into their workflow, involving crafting precise sentences and keywords to guide desired outcomes. This paper focuses on using Midjourney, a popular text-to-image GAI program, in an academic research-through-design (RtD) process within a bio design workshop. The workshop explored future cohabitation possibilities with living materials, using design fiction to gain empirical data. Midjourney was used to convert design fiction narratives into visual representations to provoke design discussion. The narratives were initially created through recordings and creative outputs. Then, each was analysed and transformed into a GAI prompt, incorporating specific descriptive elements from each workshop participant's narrative. Midjourney was effective in this context because it visually bridges the gap between the abstract nature of fiction and the tangible aspects of material design, contextualising design proposals in futuristic settings. The approach facilitated the quick generation of visual interpretations of living materials, prompting discussions on the viability of their qualities. The results underline two key insights: text-to-image GAI programs like Midjourney offer significant potential for visualising narrative-based design concepts and broader story worlds. Secondly, these programs can aid in exploring and communicating the functional and experiential qualities of new or proposed materials, improving stakeholder engagement in design education and practice and indicating one of the emerging roles of GAIs in future design processes.

Keywords: Design fiction, material design, speculative materials, text-to-image prompting

1 INTRODUCTION
Marking a milestone within the design domain, the emergence of Generative AI (GAI) models in 2022 created a new playing field for designers. Since then, GAI models have been refined daily and proved helpful as a professional design tool with a 'fun factor.' Designers increasingly use GAIs to contribute to their research, ideation, visualisation and reporting [1], [2]. Design research, on the other hand, is increasingly carrying out research around these models, seeking out their impact on practice and education [3]. Parallelly, higher education institutions (HEIs) seek legitimate ways to integrate such models into curricula to raise tomorrow's graduates [4]. Recent publications have investigated the use of text-to-image models from the perspectives of prompt crafting [5], co-creativity [6], and visualisation [7]. Research in these areas will likely grow substantially as novel features are integrated and new methodologies are developed.
Starting initially through improvision, then embedded into an academic research process, this paper presents the outcomes and potentials of a text-to-image model in a design practice context. The application area is materials and design, focusing on cohabitation possibilities with living materials in scenarios at least a decade away. Future forecasting and design fiction are necessary because living materials are not mainstream. With necessary technological and practical advances, they are predicted to slowly become part of the designer's material possibilities. To prepare and raise awareness of design, interaction, and societal potentials, this research utilised Midjourney to visualise speculative living materials whilst communicating what 'livingness' might mean within story worlds that feature artefacts or spaces made with living materials.

2 BACKGROUNDS

2.1 Biodesign

Biodesign is a design paradigm that incorporates livingness in the design processes. Myers [8] defines the field as creating designed artefacts where an organism's livingness is an essential design factor. A broader definition still needs to be made, making the paradigm yet to be clarified.

Accordingly, perspectives towards integrating living entities within design outcomes revolve around two significant milestones. The first is biofabrication as biodesign, coming from the point that every living organism is matter that designers can use and where livingness occurs during fabrication to obtain bio-based material(s). With the emergence of more-than-human discourse [9], the biodesign paradigm turned to a second milestone, in which bio-entities form the basis of living artefacts where livingness is extended into the use phase of a product, implying cohabitation possibilities between bio-entities and human users/occupants [10]. Often, living artefacts are a hybrid of conventional material(s) and organisms, which was one of the general approaches adopted in this research.

2.2 Relation of Livingness to Material Qualities

Karana et al. [11] define four potentials of materials: form, function, experience, and affordance. These potentials are realised or harnessed by designers according to the Materials Experience (MX) framework, which in its most developed version has four distinct categories of keywords/adjectives (e.g. senses, meanings, emotions, actions) [12]. However, for living materials, typical entries under these keyword/adjective categories (e.g. *fragile, natural, sustainable*) are found insufficient [13]. Instead, each category requires specialist elaboration since living materials show different qualities from conventional materials. On this point, Ertürkan et al. [14] devised a livingness vocabulary considering the unique qualities of living materials. Keywords such as *growing, decaying, temporal, dying, etc*., were proposed.

2.3 Biodesign Fiction and Investigating Cohabitation Possibilities

As one of the popular speculative spaces in design research and practice, design fiction refers to envisioning and designing an artefact or other design outcome for a probable (though often far off) future setting. Multiple media are used to construct what is referred to as a diegesis: usually, a verbal narrative intertwined with visual or tangible artefacts, which, when combined, give a speculative but persuasive character. Sterling defines design fiction as *"…the deliberate use of diegetic prototypes to suspend disbelief about change"* [15]. Accordingly, biodesign fiction, coined by Camere and Karana [16], is the merging of design fiction and biodesign to define design outcomes based on or around biological entities, which are speculative and can be positioned within probable futures. Using biodesign fiction as the theoretical foundation, this research explored the potential effects and impacts of living artefacts on user experiences (i.e., living aesthetics, mutualistic care, habitabilities, and cohabitation practices).

2.4 Research through Design Fiction

Research through Design Fiction (RtDF) is an approach to design research in which design fiction is deployed as the primary instrument for generating relevant data [17]. RtDF notably emphasises the creation of diegetic prototypes (or simulations) specifically crafted to align with a constructed narrative or diegesis, envisioned with future contexts in mind. Besides tangible assets, diegetic prototypes can be in various formats, such as narratives, scenarios, films, and drawings. These diverse forms serve as engaging and provocative gateways into the diegesis and, in the context of RtDF, serve as the primary medium for leveraging the research questions and reaching new insights and knowledge [18], [19].

3 RESEARCH DESIGN

A design fiction workshop was conducted to gain participants' insights into the speculation of futures where people cohabit or co-work with living artefacts. The research was conducted in four consecutive steps following a RtDF approach: sensitisation towards biodesign, design and implementation of the workshop, analysis of workshop outcomes, and generation (by the first author) of narratives and Midjourney visualisations.

3.1 The First Three Steps

First, a sensitisation field trip to a biodesign lab in the Netherlands was arranged. This provided an opportunity to become acquainted with living materials, converse with researchers, and help design the workshop. Nine design graduates from various backgrounds (industrial design, interior architecture, and architecture) participated in the full-day workshop by working in three groups. The participants' voice recordings and design outcomes were analysed qualitatively, principally via thematic analysis, to reveal possible futures for living material and, secondly, to evaluate the RtDF workshop as a tool for generating empirical research.

3.2 Creating the Narratives

After the thematic analysis, narratives were created by reorganising the fragmented definitions of participants' story worlds throughout the workshop into an orderly sequence. A narrative for each group was shaped by combining and selecting items that participants had mentioned based on their speculations. It is essential to highlight that these narratives were created to enhance understanding of the living material futures put forward by participants rather than forming an additional dataset. To ensure the narratives were true to original intentions, approval – and, where necessary, suggestions for adaptation or change – was sought from members of each participant group. An effort was made to interpret the story worlds with as much neutrality as possible. In creating these narratives, advantage was taken of all the materials produced and recorded during the workshop, such as internal group discussions, debriefings, the creative outcomes, and data collection sheets.

We used MAXQDA software to thematically analyse transcripts and create narratives. Keywords and relevant sentences were extracted from the data. Most narratives used direct sentences from the data, with minor adjustments for coherence. Below is an example of a part of the narrative creation process based on one of the groups' discussions. The first set of sentences from the debriefing:

> *At the beginning of this study, the two cards we drew triggered the formation of the whole. One is soil degradation, and the other is goods consumption and production. There is a state of absence. The second card we chose was the opposite of that. So, on the one hand, we are told that there is nothing, and no problem is presented. On the other hand, what could happen if you do not have such a human need comes to life in our minds. This contrast was two statically different elements from the beginning.*

Additionally, during the internal group discussions of the session, participants from the group explored reasons behind soil degradation and its possible consequences - these points are also noted, e.g.:

> *[There is] soilless farming, unplanned farming. Human mistakes killed the land. We had to give up the land to produce food.*

Accordingly, the narrative was formed as follows:

> *After years of neglect and irresponsible usage of soil to produce goods to match consumption habits, the soil on Earth has degraded so much that humans cannot cultivate and produce anymore.*

The narratives were completed and shared with the participants. No changes were requested. Three narratives, averaging 1000 words each, were created, serving as a starting point for visualising the workshop's stories and materials.

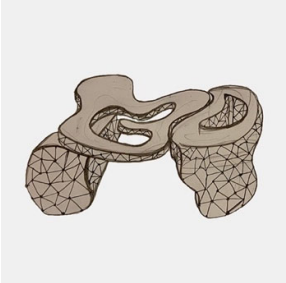
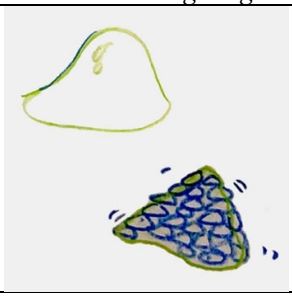
3.3 From Narratives to Speculative Living Material Visuals via Midjourney

Midjourney is a GAI program that quickly generates high-quality images from text descriptions. Designers use it for ideation, conceptualisation, visualisation, and creating images of future concepts. When employing a design fiction approach, using Midjourney's ability to synthesise keywords leads to unique and sophisticated visual results that would be challenging to achieve manually.

The narratives provided the basis for prompts that enabled the GAI program to generate images, offering vivid phrases and imaginative concepts for visualisation. From a review of research on Midjourney AI, it was possible to establish some good practices regarding prompting: 1) describe the overarching scene, for instance, *a scene of reticulated hubs made of futuristic sticky knitted material on the sea*, then 2) incorporate specific adjectives, additional descriptions, and nouns, such as *people, surfaces, futuristic, etc.*, and 3) use common adjectives, nouns, and phrases popular within the Midjourney AI community to influence the style of the images, such as *hyper-realistic, cinematic lighting,* and *intricate details*. It is worth noting that prompting is an iterative process [5], so the tool was used multiple times to produce images that best matched the narratives in the authors' judgment.

Over 200 images were created and evaluated to determine whether they should be archived or kept as examples for the narratives. The decision to keep an image as an example was based on several criteria, including coherence with the narratives and accurate representation of physical aspects and sensory elements. The example images were shared with participants to confirm their accuracy. Table 1 provides examples of participants' sketches, related narrative phrases/keywords, and Midjourney outcome.

Table 1. Comparison of a) phrases and keywords from narratives, b) participants' sketches, c) Midjourney outcome, and d) Midjourney text prompt

Phrases and keywords from narratives	**Participants' sketches**	**Midjourney outcome**
"…a novel habitat on the water / secretion of a novel marine microorganism species / affords insulation and wrapping / forming a structure for a semi-finished product that can be knitted / a form they can knit as if weaving a cloth / immense reticulated structures / habitable hubs…"		
Prompt →	*(/imagine) a scene of reticulated hubs made of futuristic sticky knitted material on the sea, people, hyper-realistic, futuristic, green cinematic lighting*	
"…a living material that can give sound which is fed on the extremity of actions carried out by people / a little slimy, soft / instantly hardens and forms crusts on it / crusts vibrate increasing a rattlesnake-like sound / it scares and needs a hiding place…"		
Prompt →	*(/imagine) a picture of a partly crusted softly seamless orbicular organic slime vibrating its crusts, hyper-realistic, futuristic, orange cinematic lighting*	
"…reflect the light / a type of camouflage for the culture / diamond / organisms live in the same habitat, which is like human skin / microorganisms in water / spraying the culture liquid on humans / human body as a catalyst for the initial chemical reaction to trigger the second…"		
Prompt →	*(/imagine) a picture of a human body sprayed by a blue liquid which makes the human body invisible, cyberpunk, hyper-realistic, blue cinematic lighting, 32k*	

4 DISCUSSIONS

In this study, Midjourney was employed to visually represent and communicate fictional concepts centred on speculative living materials. The application of GAI visualisation tools in design fiction research holds the potential for creating visual narratives of story worlds that can spark, extend, complement, or replace designers' visualisations. These points were precious for the research conducted for this paper, where the main topic (future scenarios in biodesign) and the chosen methodology (design fiction) were intended to initiate dialogue, raise questions, and stimulate discussion in areas which are inherently conceptual and discursive [20]. Utilising and embracing the discursive nature of design fiction data, text-to-image tools such as Midjourney can help open new levels of discussion, which in turn help

elaborate questions and ideas that emerge around specific concepts. In this sense, instead of implementing Midjourney as an end deliverable, the visual narratives produced via Midjourney could instead act as an initial step to deliberately drive the discussion in a design fiction workshop setting. Furthermore, since the developers of Midjourney now provide the option to use images as prompts, combining images and text may yield even tighter representations of narratives.

The narratives and the speculative materials designed through the workshop were dominantly fictional. However, the GAI's potential to represent material qualities irrespective of fiction or reality was apparent even with short prompting. Through carefully selecting which aspects of materials are planned to be shown and using a purposeful definitive vocabulary [14], [21], the functional and experiential qualities of materials can be visualised or anticipated through text-to-image models. Furthermore, introducing images as prompt inputs allows speculative materials to be embodied in foreseen artefacts or other physical entities. Direct mapping of fiction and reality may offer great benefits for investigating material experiences around specific product design proposals. However, this issue needs further research on crafting prompts to represent material qualities and measuring their success in representing such qualities. Effective communication of experiential qualities of materials can be difficult because the affective and interpretive levels of materials experience are highly subjective [21]. Today, it is commonplace for a design school to teach visual communication skills to help novice designers communicate their design concepts, including materials communication. In a broader sense, GAI might be a more efficient and faster alternative for communicating such concepts. It may help educators deliver design curricula that focus more on the changing problems of the real world [22].

Despite the study underscoring the significant potential of GAI tools like Midjourney in visualising speculative materials, there are potential drawbacks to utilising such tools in the first place. GAI tools offer unique benefits in rapidly creating diverse visual representations. Yet, the potential biases in GAI-generated images and the challenges such as accurately representing living materials' qualities, reinforcement of existing stereotypes and the lack of diversity in generated outputs must be considered, along with broader issues around these tools, such as their effect on human creativity, copyright issues and causing misuse and misinformation scenarios. Also, analysing the outcomes of Midjourney and human sketches comparatively, while GAIs can produce compelling images, the depth of understanding and the scrutiny often captured in human sketches may be lacking. Also, human sketches, including the designer’s intuition and creativity, still pose a challenge for GAIs to replicate. Hence, a nuanced utilisation of GAI tools in design processes will remain a prominent research subject.

5 CONCLUSIONS

There is increasing interest in using both GAI tools and design fiction in design education, but currently, only some examples of practices and applications exist. The paper has presented a systematic implementation of a text-to-image GAI tool, namely Midjourney, as the final step in a RtDF process to communicate story worlds and speculative material qualities. Text prompts for Midjourney were carefully crafted from narratives extracted from a generative design fiction workshop. The workshop delved into potential future user/human scenarios with living materials, employing design fiction to collect a pool of ideas for analysis.

The use of Midjourney in this research underscores the potential of text-to-image models to effectively bridge the conceptual gap between the speculative nature of design fiction and the tangible nature of materials in design. The findings highlight the significant role of GAIs in expanding the possibilities for design and material communication. GAIs could revolutionise how design education and practice communicate conceptual ideas – in this case, material designs – from early abstract versions to refined and developed proposals. A systematic evaluation of GAI tools to communicate specific material qualities is needed to establish the value of such tools within designers’ materials decision-making.

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