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CAPABILITIES OF AI IN TEXT-TO-3D MODEL GENERATORS FOR MECHANICAL COMPONENTS DESIGN

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Introduction

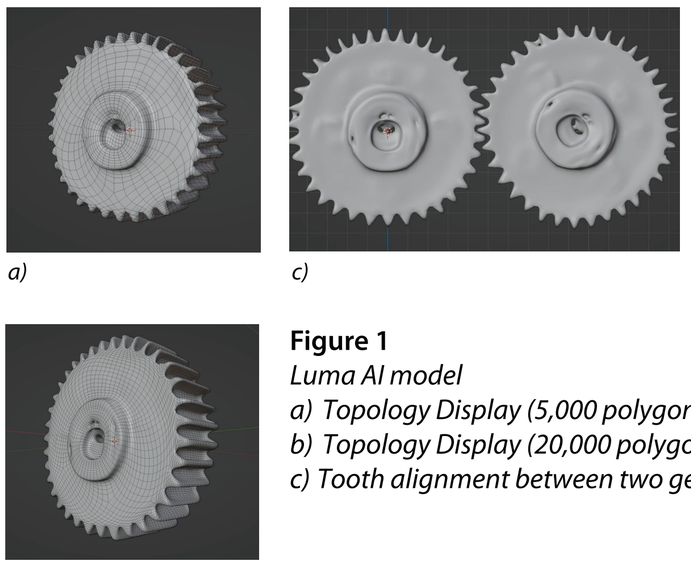
AI 3D model generators use artificial intelligence and advanced algorithms to create three-dimensional models based on textual descriptions, images, and even video inputs. It enables the automated production of 3D models from a variety of input sources, which can then be used for applications such as virtual reality, augmenter reality, entertainment, or in robotics and autonomous vehicles (Tsalicoglou, C. et al. 2024). These tools offer a wide range of functionalities, including real-time full-body motion capture, applications in gaming and architecture, artistic video creation, while others excel in full-body marker tracking or texture generation, as well as capturing high-quality geometry. Each of these generators has its own strengths made up for specific needs in design and visualization (Unite AI, 2024).

Problem Description

This paper investigates the effectiveness of current AI technologies in translating text prompts into accurate and functional 3D models of mechanical components, with a specific focus on spur gear. The aim is to determine if these generators can provide an accurate and viable model, assessing their effectiveness in reducing the time and expense associated with traditional mechanical design and production processes, while also identifying any limitations in their current capabilities.

Methods

Three different AI 3D generators were used to create 3D models from a text prompt: Luma AI (Luma AI, 2024), Meshy AI (Meshy AI, 2024), and Rodin AI (Hyperhuman, 2024). These generators were selected based on their availability and the variety of features they offer for different applications. Each of the generators was tasked with interpreting the same prompt to ensure consistency in the testing process.
The text prompt used for generating the 3D model was as follows: "spur gear: 30 teeth, module 2 mm, 60 mm pitch diameter, 20° pressure angle, 10 mm gear width".



a) *c)* *b)*

Figure 1
Luma AI model
a) Topology Display (5,000 polygons)
b) Topology Display (20,000 polygons)
c) Tooth alignment between two gears

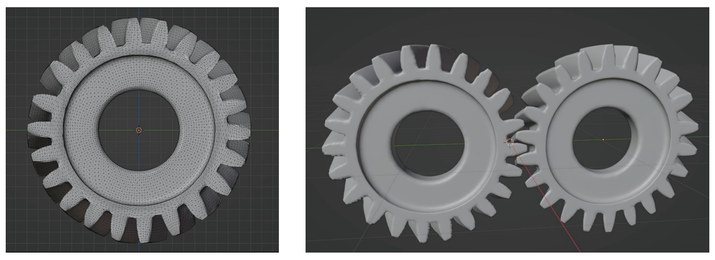
Results

3D generator Luma AI

The text prompt resulted in a model of an individual gear, featuring a random number of teeth, arbitrary dimensions, tooth angles, and hole diameter. However, the resulting 3D model is not adequately shaped; it exhibits uneven characteristics, gaps between the teeth, and the hole is misaligned. Despite these issues, the topology of the model; with the "Low" (Figure 1a) and "Med" (Figure 1b) options selected; remains relatively neat and organized. Tooth alignment between two gears is shown in Figure 1c.

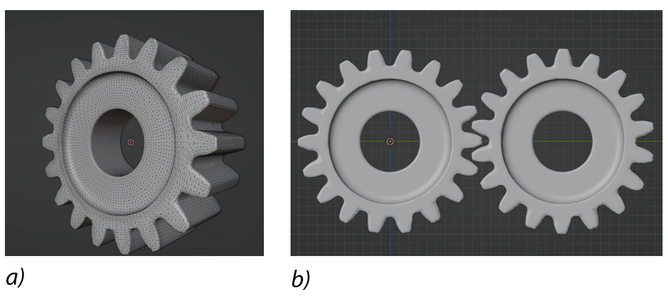
3D generator Meshy AI

Two out of the four variations were selected for their accuracy, as they displayed no significant irregularities or geometric artifacts.
The first selected variation is an individual gear with random dimensions and a variable number of teeth, exhibiting a slanted horizontal angle. It turned out to be quite accurate, with only minor geometric irregularities (Figure 2a). Tooth alignment between two gears is visualized in Figure 2b.
The second selected variation is also an individual gear with random dimensions and a variable number of teeth, but it features a correct and uniform shape with straight teeth, equal spacing, and a centered hole, again displaying only minor geometric irregularities (Figure 3a). In Figure 3b tooth alignment between two gears can be seen.



a) *b)*

Figure 2 *Meshy AI second model*
a) Topology Display b)Tooth alignment between two gears



a) *b)*

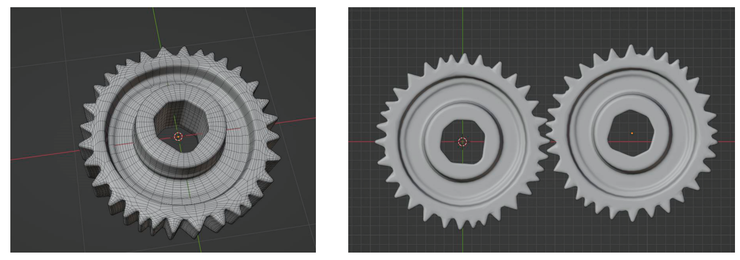
Figure 3 *Meshy AI first model*
a) Topology Display b)Tooth alignment between two gears

3D generator Rodin AI

The generation time for 3D Rodin AI was less than a minute. By inputting the textual prompt, a single gear with random dimensions and parameters was generated. It exhibits a correct round shape and a centered hole; however, it features irregular and uneven teeth of varying sizes and spacing. The topology is neat and moderately dense, consisting of 10,000 polygons, although the geometry of the teeth remains irregular (Figure 4a). Visualization of tooth alignment between two gears can be seen in Figure 4b.

Discussion / Conclusion

Model generated from 3D generator Luma AI is unsuitable for any real and practical use such as 3D printing, meaningful simulation, or 3D animation. However, the polygons create irregular tooth shapes, which limit the model to only potential digital use where precision is not critical. The 3D generator Meshy AI produced four variations, of which two were selected. The first selected variation is relatively adequate in shape for use in a real mechanism or prototype (3D printing). Its topology is neat and moderately dense, consisting of 50,000 polygons, making it suitable for simple 3D models where high resolution is not necessary; however, this density may represent an excess in terms of system optimization or computer performance. The second selected variation is also relatively adequate in shape for use in a real mechanism or prototype (3D printing). Its topology is neat and denser, similar to the previous example, with approximately 50,000 polygons. The 3D generator Rodin AI produced a gear model that is neither adequately shaped nor suitable for practical use in a mechanism or prototype (3D printing).
Overall, while these AI tools showcase notable advancements in automated 3D modeling, they still require improvements in precision and usability to meet the demands of real-world mechanical applications. Further development will be needed to improve the practicality of these tools for engineering and design applications.



a) *b)*

Figure 4
Radin AI model
a) Topology Display (10,000 polygons)
b) Tooth alignment between two gears

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