APPLICATION OF PREFERENCE SELECTION INDEX (PSI) METHOD FOR SELECTING A 3D PRINTER

ÁP DỤNG PHƯƠNG PHÁP PREFERENCE SELECTION INDEX (PSI) ĐỂ LỰA CHỌN MÁY IN 3D

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ABSTRACT

3D Printing is increasingly used in many fields such as: Medicine and Dentistry, Aviation, Automation, Jewelry, Architecture, and Fashion, etc. To achieve high efficiency in printing process, the first well-thought-out step is choosing a 3D printer. There are many types of 3D printers manufactured by different brands on the 3D printer's market and each type has all the parameters (criteria) to evaluate is not the same. This makes for the customers very complicated and confused to select a 3D printer. This study applied a type of Multi-criteria Decision Making (MCDM) in machine selection, called Preference Selection Index (PSI). Six 3D printers from five different manufacturers were used including Creatbot DE plus, Flashforge Creator 3, Cubicon Style NEO A22C, Single Plus - 320C, LulzBot TAZ Pro, and CraftBot Flow White IDEX. This article showed that Creatbot DE plus is the best choice, on the contrary, Cubicon Style NEO A22C is the worst selection. And then the orientation of selecting a 3D printer is also mentioned in the last part of this research.

Keywords: *Selecting a 3D printer, Multi-criteria decision making, PSI method.*

TÓM TẮT

Công nghệ in 3D ngày càng được sử dụng rộng rãi trong nhiều lĩnh vực khác nhau như: Thuốc và Nha Khoa, Hàng Không, Tự Động Hóa, Trang Sức, Kiến Trúc, Thời Trang... Để đạt được hiệu quả cao của quá trình in thì việc làm đầu tiên phải được xem xét một cách cẩn thận đó là lựa chọn máy in. Trên thị trường có nhiều loại máy in được sản xuất bởi nhiều hãng khác nhau, trong mỗi loại máy đó thì các thông số (tiêu chí) để đánh giá cho mỗi loại máy cũng không giống nhau. Điều này làm cho việc lựa chọn máy in là một công việc phức tạp, gây bối rối cho khách hàng. Nghiên cứu này đã áp dụng một phương pháp ra quyết định đa tiêu chí để lựa chọn máy in. Phương pháp đã được sử dụng có tên gọi là Preference Selection Index (*PSI*). Sáu loại máy in của năm hãng khác nhau đã được xem xét gồm Creatbot DE plus, Flashforge Creator 3, Cubicon Style NEO A22C, Single Plus - 320C, LulzBot TAZ Pro, và CraftBot Flow White IDEX. Nghiên cứu đã chỉ ra rằng Creatbot DE plus là loại tốt nhất, ngược lại Cubicon Style NEO A22C là loại tồi nhất. Sau cùng định hướng cho các nghiên cứu tiếp theo trong việc lựa chọn máy in 3D cũng đã được đề cập đến trong nghiên cứu này.

Từ khóa: *Lựa chọn máy in 3D, ra quyết định đa tiêu chí, phương pháp PSI.*

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1. INTRODUCTION

3D printing technology is a series of steps that overlap successively thin layers of material into a tangible three-dimensional object based on a digital model [1]. This technology is increasingly widely used in many fields such as: Medicine and Dentistry, Aviation, Automation, Jewelry, Architecture, Fashion, and more [2-5]. Recently, on the 3D printer's market, there are many different types of 3D printers, selecting a printer that is considered the most suitable often makes it difficult for customers. It can be said that because there are many criteria to evaluate the 3D printer such as the size of the product to be printed, the accuracy and flexibility of the machine in the working process, the thickness of printing layer, of course, that includes the cost of the machine, etc [2, 6, 7]. However, these criteria are sometimes contradictory between printers, for example, low-cost printers have poor flexibility or limited accuracy. Therefore, choosing a printer that is considered "most suitable" or "best" becomes complicated for the customers. In this case, *MCDM* is seen as an effective support tool for customers. Some *MCDM* methods have been also studied in this field such as: Using *TOPSIS* method [8, 9]; using *fuzzy TOPSIS* method [10]; using *Deng's Similarity* method [11], combining *GRA* method and *TOPSIS* method [12]; Use the *Proximity Indexed Value (PIV)* method [13]. Some research have also simultaneously combined many different *MCDM* methods to select 3D printers, such as: simultaneously using three methods including *AHP fuzzy, VIKOR* and *ELECTER* [14]; simultaneously using three methods including *TOPSIS, Deng's Similarity*, and *PROMETHEE* [15]; etc.

So, it can be seen that *MCDM* methods have been applied quite a lot in the selection of 3D printers. Nonetheless, in all the studies mentioned above, when performing the ranking for printer selection, it is essential to determine the weights for the criteria. This is a rather complicated task for decision makers (customers) because the weight of the criteria has a great influence on the ranking results of the options [16-18]. If there is a mistake in determining the weights for the criteria, it will make the ranking of the solutions not accurate, that is, the best

solution cannot be selected in a real way. This limitation will be improved if some *MCDM* methods is used without specifying weights for the criteria. *PSI* method is a method that meets this requirement [19]. Based on this advantage, the PSI method has been applied to rank the alternatives and then choose the best one in many different fields: measuring the performances of the machines [20], ranking of waste recovery alternatives [21]; developing a student scholarship decision support system [22], optimization selection of ceramic particulate reinforced dental restorative composite materials [23]; decision making over the design stage of production system life cycle [24]; optimization of turning process parameters [25]; determining the location of used laptop marketing [26]; comparison of tourism potentinals [27]; machine selection in a flexible manufacturing cell [28]; to select personnel for a textile company in Turkey, to select an industrial robot, to select a turning process, and to evaluate the air quality in the office [29]; to select individuals eligible for credit loans from banks [30]; to select the outer circular grinding process [31]; etc. However, despite taking a lot of time and effort, the author of this research has not found any studies that applied *PSI* method in 3D printer selection. This author conducted this research and reasonably so. The next sections of this paper are structured as follows: in part 2, steps are presented to rank the options according to the PSI method. A case of applying PSI method to 3D printer selection is done in part 3 of this paper. The conclusions of this study and the work to be done in the future are summarized in the conclusion of this paper.

2. PSI METHOD

According to PSI method, the order steps are arranged as follows [19]:

- Build a decision matrix consisting of m alternatives and n criteria.

- Calculate the data

+ For the bigger criteria is better ranking.

$$N_{ij} = \frac{y_{ij}}{y_j^{max}} \quad (1)$$

+ For the smaller criteria is better ranking.

$$N_{ij} = \frac{y_j^{min}}{y_{ij}} \quad (2)$$

- Calculate the average of normalize data.

$$N = \frac{1}{n}\sum_{i=1}^{n} N_{ij} \quad (3)$$

- Determine the preferred value from the average value.

$$\varphi_j = \sum_{i=1}^{n}\left[N_{ij} - N\right]^2 \quad (4)$$

- Determine the deviant value from the preferred value.

$$\emptyset_j = \left[1 - \varphi_j\right] \quad (5)$$

- Determine the overall priority value for the criteria.

$$\beta_j = \frac{\emptyset_j}{\sum_{j=1}^{m}\emptyset_j} \quad (6)$$

- Scored (PSI) for each criteria.

$$PSI_j = \sum_{j=1}^{m} N_{ij} \cdot \beta_j \quad (7)$$

- Ranking of the best alternative is followed by the result with a maximum PSI_i and vice versa.

3. SELECTING A 3D PRINTER BY PSI METHOD

Six 3D printers were given to select including: Creatbot DE plus (A1), Flashforge Creator 3 (A2), Cubicon Style NEO A22C (A3), Single Plus - 320C (A4), LulzBot TAZ Pro (A5), and CraftBot Flow White IDEX (A6). Ten criteria were used to evaluate for each of them including:

C1: Layer Thickness (mm);

C2: Maximum Printing Speed (mm/s);

C3: Power Consumption (W);

C4: Maximum Extruder Temperature (^{0}C);

C5: Accuracy of XY Axis (μm);

C6: Accuracy of Z Axis (μm);

C7: Maximum Size of Printed Object in The X Direction (mm);

C8: Maximum Size of Printed Object in The Y Direction (mm);

C9: Maximum Size of Printed Object in The Z Direction (mm);

C10: Cost ($).

Information about six 3D printers that should be ranked was compiled in Table 1. The data for this table was obtained from the website of their company [32-37]. Among them, for C1, C3, C5, C6 and C10, the smaller of each criteria is, the better the ranking gets, conversely, for the rest of criteria, the bigger of each criteria is ranked better.

Table 1. Information about six 3D printers [32-37]

No.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0.05	200	360	350	12.7	1.25	400	300	520	4299
A2	0.05	150	500	300	11	2.5	300	250	200	2999
A3	0.1	150	600	260	3.125	1.25	220	220	220	3200
A4	0.1	500	600	260	6.25	1.25	240	190	200	2560
A5	0.05	200	500	290	10	1	280	280	285	4950
A6	0.05	200	500	300	12.5	5	300	200	250	2699

The steps are as follows:

- Creating a decision matrix, as shown in Table 1.

- Formulas (1) and (2) were used to calculate for each alternative, the results were performed in Table 2.

Table 2. Calculated value for the criteria

No.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	1.0000	0.4000	1.0000	1.0000	0.2461	0.8000	1.0000	1.0000	1.0000	0.5955
A2	1.0000	0.3000	0.7200	0.8571	0.2841	0.4000	0.7500	0.8333	0.3846	0.8536
A3	0.5000	0.3000	0.6000	0.7429	1.0000	0.8000	0.5500	0.7333	0.4231	0.8000
A4	0.5000	1.0000	0.6000	0.7429	0.5000	0.8000	0.6000	0.6333	0.3846	1.0000
A5	1.0000	0.4000	0.7200	0.8286	0.3125	1.0000	0.7000	0.9333	0.5481	0.5172
A6	1.0000	0.4000	0.7200	0.8571	0.2500	0.2000	0.7500	0.6667	0.4808	0.9485

Table 3. Some parameters of PSI

No.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
φ_j	0.3333	0.3533	0.1069	0.0452	0.4311	0.4533	0.1238	0.1089	0.2771	0.1855
$\varnothing_j$	0.6667	0.6467	0.8931	0.9548	0.5689	0.5467	0.8763	0.8911	0.7229	0.8145
β_j	0.0879	0.0853	0.1178	0.1259	0.0750	0.0721	0.1156	0.1175	0.0954	0.1074

Using formulas (3), (4), (5), và (6) determined the parameters φ_j, $\varnothing_j$, and β_j presented in Table 3.

Formula (7) was used to scored (PSI) for each option. The results of the calculation were given in Table 4. The rankings of all alternatives according to the scored value PSI were also summarized in this table.

Table 4. The score and the ranking of each alternative

No.	PSI	Rank
A1	0.8344	1
A2	0.6694	4
A3	0.6426	6
A4	0.6766	3
A5	0.7052	2
A6	0.6608	5

Based on the data shown in Table 4, the ordinal ranking of the alternatives is A1 > A5 > A4 > A2 > A6 > A3. In other words, Creatbot DE plus is the best 3D printer, LulzBot TAZ Pro comes in second place, the third place belongs to Single Plus - 320C, Flashforge Creator 3 and CraftBot Flow White IDEX are ranked 4th and 5th respectively. Finally, Cubicon Style NEO A22C is the worst 3D printer.

4. CONCLUSION

This study applied *PSI* method to select a best 3D printer from six available 3D printers. Ten criteria are used to describe for each machine, in which, this article used 2 categories as the bigger criteria is better ranking and the smaller criteria is better one. The advantage of *PSI* method over with the other types of *MCDM* method is that it is not necessary to determine the weights of criteria. This makes less of a difference for the customers. As a result of this research, six 3D printers were reviewed including Creatbot DE plus, Flashforge Creator 3, Cubicon Style NEO A22C, Single Plus - 320C, LulzBot TAZ Pro, and CraftBot Flow White IDEX. Summarizing, Creatbot DE plus is the best selection.

For the selection a 3D printer, besides the criteria were given in this research, shape, aesthetics, warranty and promotion are essential things to be considered. This is the direction of the future study in choosing a 3D printer.

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