J. Appl. Comput. Mech., 6(4) (2020) 841-847
DOI: 10.22055/JACM.2019.29701.1628

ISSN: 2383-4536
jacm.scu.ac.ir

M&MoCS
Shahid Chamran University of Ahvaz

Journal of
Applied and Computational Mechanics

Research Paper

Designing and Creating a Mouse Using Nature-Inspired Shapes

Abolfazl Foorginejad[1], Mohammad Lakhi[2]

[1] Department of Mechanical Engineering, Birjand University of Technology, Birjand, Iran, Email: foorginejad@birjandut.ac.ir
[2] Faculty of Engineering, University of Birjand, Birjand, Iran, Email: m.lakhi@birjand.ac.ir

Received May 24 2019; Revised July 07 2019; Accepted for publication July 28 2019.
Corresponding author: A. Foorginejad (foorginejad@birjandut.ac.ir)

Abstract. Human beings have always made their tools and instruments they need using patterns in nature. Mimicking nature has become the foundation of a new science called Biomimetics. In the present article, multiple forms and levels in nature were utilized to design and create a mouse. The rivers are a good source for choosing the shape of a mouse with lots of stones abraded through the centuries which also have smooth surfaces. In this research, a significant number of stones fitted to hand size were collected and then the best ones were scanned by an optical scanner. The point cloud model obtained was used to design and create the mouse and determine the geometric parameters of the mouse. After extracting the 3D model of the point cloud using a rapid prototyping technique with the Fused Deposition Modeling (FDM) method, some mouse models were designed ambidextrously for left-handed and right-handed people. Considering the results of the mouse evaluation by 30 people who were provided with the mouse, it can be concluded that the created mouse provided a high rate of satisfaction.

Keywords: Biomimetics, Mouse, Reverse engineering, Rapid prototyping

1. Introduction

The 4.6 billion years old earth, hosting life for 3.8 billion years and enjoying a rich variety of living and non-living organisms are considered to be a huge investment. Considering the significant benefits that nature offers, its use has been inspirational to a significant number of designs and innovations. The study of natural forms, the cycles of natural products as an inspirational source and familiarity has been revealed for professionals, designers, and manufacturers in designing a new generation of industrial products. Actually, nature is a brilliant teacher resembling a valuable book for humans in designing and optimizing engineering issues.

One of the principles of biomimetic is the use of nature as a model. Biomimetic is a new science that studies existing models in nature and then by mimicking or getting inspired by the design, shape, or its process begins solving human problems [1]. Biomimetics explains how nature inspires the creative design of products and how the principles of this science can be used for proper design [2,3]. There are several nature-inspired designs and there are many examples of human imitation for solving problems and optimizing issues through biomimetic. Animal shapes or their parts are used extensively in designing the car body and parts. these designs not only have the characteristics of appearance and beauty, but they also possess the physical and aerodynamic properties of nature, e.g. the headlights in Peugeot 206, Toyota Previa, Citroen Xsara, Ford Puma and Ford Cougar which are designed like cat eyes, or Ford Cougar front design which is inspired by the American cheetah's face [4]. Also, Kozlov et al. [5] used the Aerodynamic characteristics of boxfish for design and They studied the aerodynamic behavior in CFX FLUENT software and Wind tunnel. Similarly, Choi et al. [6] presented a study of fluid flow based on morphological features of living creatures. Zari [7] also reported on biometric approaches to design for increased sustainability.

The design of solar cells is inspired by the leaf, moreover, the leaf pattern of trees can be used for self-cleaning as well as anti-reflection properties in solar cells [8]. The robotics development, the creation of tools using living beings' behavior and the creation of prostheses to approximately imitate the real organs with microchips to enhance sensitivity and communication with the brain are among the other benefits of biomimetic science [9].

In 2004, Padbrouchi and Vakalenso [10] used natural shapes and inspirations as a source of inspiration for designs. In 2007, Camps et al. [11] began to systematically design biomimetic for mass production of industrial components. In the same year, Ikeda et al. [12] conducted a study on designing a powerful biomimetic blade for small wind turbines and concluded that designing turbines using biomimetic science could be a practical and effective method concerning turbines and their reinforcement. Bridges and their design are another engineering issue that can be used in different dimensions, namely, geometry, structure, and mechanism in nature. In this regard, Ho et al. [13] designed innovative bridges using the above science.

Nowadays, with the advent of technology, the use of computers and, consequently, the use of the mouse is an inseparable part of everyday life. Considerable use of the mouse has now become a physical issue, including the risk of upper muscular-skeletal disorders, and that muscle pressure should be mitigated by designing an appropriate mouse [14]. Bamak et al. [15] investigated the effects of computer use in the long-term, and in the same year, Kampra et al. [16] studied the syndrome of overusing the mouse. In 2016, Goodz and Kiel [17] also studied the effect of the mouse's position on muscular and topical stress.

In particular, in the field of mouse design, as well as design optimization for different uses in computers, a large body of research has been done, but not in the field of biomimetic. Research in this field was conducted to make people more comfortable in using the mouse and increasing its efficiency. In 2015, Oled and Johnson [18]. evaluated the flat, angular, and vertical mice, and their effects on the position of the wrists, and showed the function and priority of using each one. Also, Wei Li and Chu Lei [19] designed and corrected it for the mouse wheel for multiple applications. In 2015, Dehghan et al. [20] also designed a new mouse and evaluated some of its functional parameters.

The present study used an innovative idea for designing a mouse tailored to the dimensions and geometry of human hands. Considering the fact that computer models are untouchable by the user's hand, and the possibility of a 3D printing of a significant number of models to evaluate how they are placed in the hands of a person is quite a time consuming and costly, thus, in this study, objects in nature were used as alternatives to this process. To this aim, a significant number of river bed rocks were collected and their geometry and shape were used to design and create a nature-inspired mouse, and finally, the best pattern for making an ambidextrous mouse for people was used by a 3D printer. The prototype mice were evaluated by many people in terms of size and manner of position in the hands.

2. Mouse Design and its Importance

As said, nowadays, the use of computers has considerably increased and its use has become inevitable. Meanwhile, nowadays, the mouse is one of the most practical and adequate tools for data input using its motion and selecting topics in the computer. The most significant mouse action for understanding the computer is detecting the direction and speed of movement by sensors and equating it to computer-readable signals.

The computer mouse is a mouse-like device and, like the keyboard, is a hardware interface, including computer input devices. Actually, today, the mouse tool with the keys embedded on it is also responsible for many keyboard tasks, increasing the ease and thus the efficiency of working with the computer.

Initial computers lacked the mouse, however, with the advent of graphical interfaces like Windows, the need for navigating and selecting in the environment of such operating systems was completely felt, therefore, there was a lot of effort to create a tool for moving, selecting and ordering the program execution. At the beginning of 1953, the Royal Canadian Navy designed a military instrumental project in a completely confidential military project, but what is now recognized as a mouse is designed and documented by American Dr. Douglas Engelbart in 1963. His design was a small box that recorded movements in two directions by two vertical wheels and could be located by the movements of the hand similar to the current mice, it led to the creation of a functional instrument called mouse, like what it is today.

After creating the prototype by Dr. Inglebert, mice were produced in different sizes, shapes, applications, and mechanisms. Nowadays, the most commonly used mice are the lasers types, in which no mechanical parts are used, and the speed and precision of the mouse are highly enhanced for greater efficiency. In laser mice first marketed in 2004, there is a cavity for radiation and reflection of light or laser. First, the light is radiated on a glass with a constant angle and reflects it from the cavity on the motion surface, after which an electronic chip as an electric eye records several low-resolution images to determine the direction of the mouse movement.

Currently, the mouse manufacturers focus on the production of a mouse with easier use and less physical pressures caused by its use along with further speed and precision for mouse function. In this regard, much effort is made to create different types of a mouse using ergonomic science to increase the comfort of the individuals in using the mouse and to produce an optimal mouse in this field, however, unfortunately, less attention is paid to biomimetic, in which nature-inspired mouse is designed.

3. Mouse Prototyping

In today's life, where computer systems are widely used, the use of a device tailored to the human body to reduce the destructive effects of these devices becomes more and more important. In the meantime, utilizing nature for optimal design with respect to biomimetic will be beneficial, and proper design will reduce the destructive effects of using the mouse tool.

According to the mentioned references, the increasing use of computer mouse in everyday life has caused serious injuries to the human wrist. These injuries are sometimes due to inappropriate mice. wrist position and perfect matching of the mouse with the hand are the most important causes of injury [21,22]. For this reason, in this research, it was tried to make a mouse inspired by nature in accordance with references and biomimetic which has the least injuries on the body. One of the things that is very much viable in nature and is in perfect matching with human hands is the rock. Rocks are perfectly polished and smooth. The rocks, with their geometry as the mouse, can easily cover the space of the hands when working with the computer and match with the hands of people.

In order to find the proper design for the mouse, the present research selected several rock samples inspired by the nature from the river bed. Selected rocks are perfectly polished and smooth considering the collection area because over time the river has removed the roughness of these rocks to be as polished as possible. In the initial stage of the nature-inspired mouse design, creating a visual filter to select several stones is more appropriate than the massive amount of stones. The selection criterion at this stage was in addition to the visual filter, precision, and rate of matching in hand position.

After identifying and selecting several stones, we surveyed several people who constantly used the computer and the mouse, and among these rocks, according to the comfort and satisfaction of the people, the appropriate rock for use in the mouse design was selected (Figure 1).

Fig. 1. Criterion stone for mouse design

A 3D scanner was used to design and construct a mouse proportionate to the criterion and nature-inspired stone, to make the point clouds model available. After creating the point clouds model of the criterion stone by the 3D scanner, a 3D model was designed according to figure 2 and 3 by the Solidworks software in two right and left-handed states.

In order to create a mouse to measure the comfort of people in using it, the design of two right and left hands was used and then these two mice were produced with a 3D printer. After creating the upper and the bottom surface of the mouse, an electronic chip was also provided and the model was assembled for use.

Fig. 2. Designing and the prototyped left-handed mouse

Fig. 3. Designing and the prototyped right-handed mouse

4. Results and Discussion

The appearance and design of the mouse are one of the important factors in the application and reduction of its destructive effects, therefore, as explained, the biomimetic science was used to understand the proper geometry. For proper design, first, by using visual selection and adaptability with palms, several stones were selected at the river bottom among several stones and then, by asking different people, the most suitable stone was chosen as the criterion. Then, using a 3D scanner, the point cloud model was provided. For the biomimetic design process, a 3D scanner and the point cloud can be used directly to study the shape of the hand's palms in order to create a suitable mouse geometry.

In order to recognize and determine the appropriate geometry for the mouse, the point cloud model was called in Geomagic software. Then, in the above software, the important pages in the design were identified and the normal vector was determined for each of the levels to determine the angles of each surface with the coordinate plane (Figure 4).

One of the cases that made the created mouse be desirable for users is its geometry. A part of this mouse is higher than the rest of the mouse, and the higher part acts as a rest for the joints of the fingers and is used as a reliance on the surface (area 3 in Figure 4), which is a quite special feature of the present mouse, making it more distinct from the existing mice. There are two plates on both sides of this section, one of which is the palm position (level 1 in Figure 4), and the other is the position of the fingers (level 2 in Figure 4), which follows the shape of the palms and fingers. The presence of different parts of the mouse for positioning the sixth finger, the other fingers and palms made the user satisfied in getting the mouse in hand, and like the vertical mice, the hand is positioned in a state similar to shaking hands. The set of factors has made the designed mouse user-friendly. The angles of the plates for hand part positioning are less than the vertical mouse, and the normal vector was calculated for obtaining plates angle in the first step to obtain the points related to each plate in the point clouds. In the present study, the covariance matrix method was used to calculate the normal vector of the calculation level. For the desired point $P_i \in S \subset R^3$, the normal vector is estimated based on the neighbor coordinates. Neighbors are represented by the symbol $N(P_i)$ and N refer to the closest proximities k belonging to P_i, where k is selected based on the need, and in this study, 20 neighbors were used to estimate the normal surface vector [23]. In order to calculate the normal vector, the Oicenter pertaining to NPi is first computed.ni of the normal vector is estimated using Principal Component Analysis (PCA). In order to measure the normal vector, the related covariance matrix NPi is calculated based on Eq. (1).

$$M_{\text{cov}} = \sum_{x_i \in N(P_i)} (X_i - O_i)(X_i - O_i)^T \tag{1}$$

where X_i is one of the k neighbors of the P_i point and O_i is the center of the neighbors.

In this method, the normal vector of the surface is obtained by calculating the special vector pertaining to the least covariance Matrix Eigenvalues. Considering the mean of normal vectors [24], on the first page of the normal vector equal to -0.171, 0.941, 0.292 and for the normal vector of the second plate -0.586, 0.734, -0.344 were obtained. Considering the calculated normal vectors and the normal vector of each coordinate plate for each plate according to equation (2) the angle of the surfaces with the coordinate plates is calculated, which accordingly, the angles of each surface are extracted based on Table 1 considering Figure 4.

After recognizing the surfaces and designing appropriately using the existing point cloud model, the satisfaction level of the individuals regarding the present mouse was questioned. To this aim, using the extracted point cloud model, the final and proper design of the mouse was done for general use, using Catia software. Then, based on the design conducted, using 3D printers, two samples of the mouse were produced in accordance with Figures 2 and 3. The created mouse was used to measure people's satisfaction through field research. In the field research, two groups of right-handed (N =26) and left-handed (N = 4) in each gender (female 14 and male 16) were asked in the age range 10 and 43 years, about the satisfaction of using the above mouse. In Figure 5, the degree of satisfaction (out of 20 points) each of these cases is illustrated. On average, in the present study, as shown in Figure 5, people assigned a score of 18 to the above mouse, which is an appropriate score for designing this nature-inspired mouse.

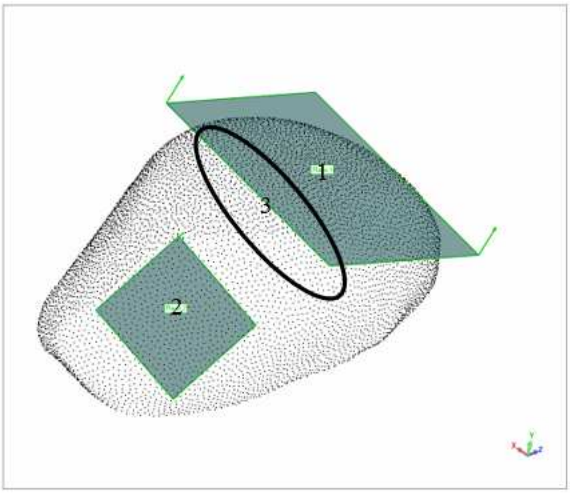

Fig. 4. Point cloud model

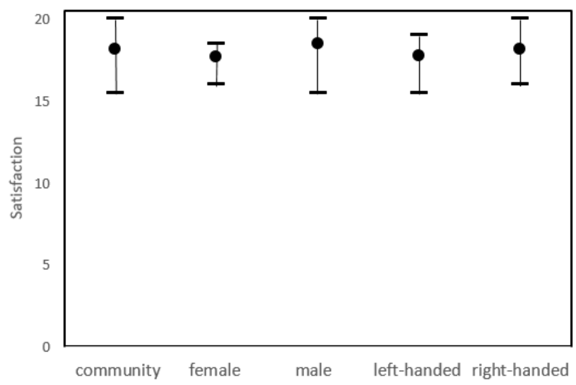

Fig. 5. Satisfaction in different groups

Table 1. Angles of surfaces with coordinate plates

Surface 1	Angle with plate xy	73.022
	Angle with plate yz	80.154
	Angle with plate zx	19.779
Surface 2	Angle with plate xy	69.884
	Angle with plate yz	54.136
	Angle with plate zx	42.792

The satisfaction level of the people derives from the comfort of using, i.e. the manner of the positioning of the mouse in the hands or its user-friendliness. In order to explore the reason beyond the dissatisfaction of some people in using the above mouse, the area of the palm (as illustrated in Figure 6) was measured for the whole population.

After measuring the length and width of the palms of each person, the area of the palm is considered as a measure of the level of satisfaction and user-friendliness of the mouse. Figure 7 presents the degree of satisfaction in terms of the people's area of the palm. Approximately, the area of the palm is a proper criterion for the rate of satisfaction. Because, relatively, based on Figure 7, people with smaller area had lower satisfaction and, conversely, people with bigger palm had more satisfaction with the use of the mouse, e.g. a person with the palm area of 102.96 mm square, scored it 15.5, and on the opposite, people with a palm area of 216.32 mm square, scored 20 to the satisfaction rate of the mouse. Obviously, in order to fully satisfy each individual, it is necessary to select the stone in accordance with the palm and design and create a proper mouse.

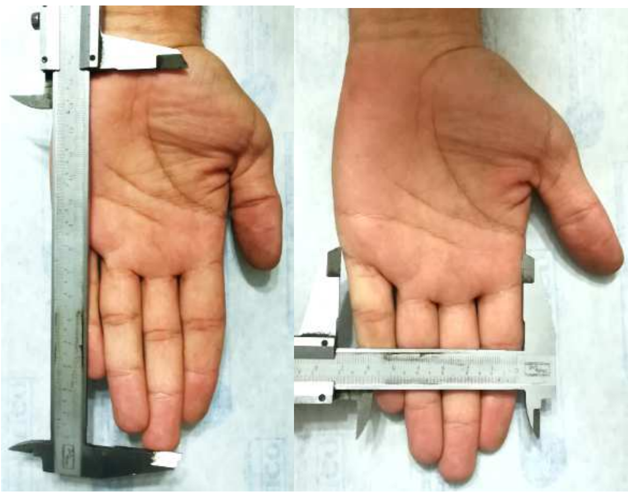

Fig. 6. Measurement of the length and width of the hand palm

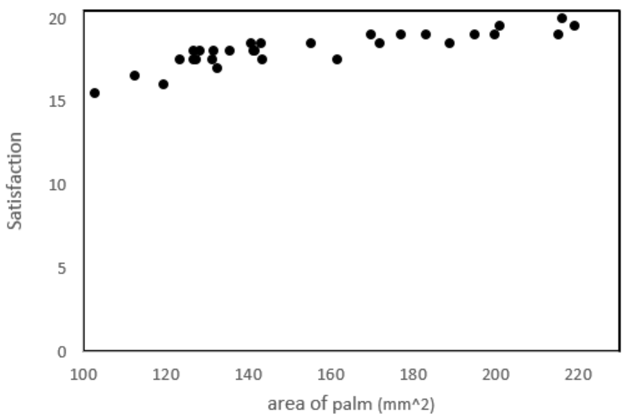

Fig. 7. Diagram for the rate of satisfaction in terms of the people's palm

5. Conclusion

Using and modeling nature in order to make applicable tools and instruments is the basis for the creation of modern science called biomimetic. In the present research, the mouse model was designed and developed considering this science. Therefore, several stones were selected and separated from the bottom of the river bed due to surface quality. Then, among the selected stones, the most appropriate item was selected as the criterion in terms of positioning in the palm of the hand. The criterion stone was prepared by a 3D scanner of the point cloud model and then using the point cloud model the surface of the mouse was identified and designed. According to the design, the mouse model was created with a 3D printer. Due to the identification of the mouse plates and its angles with coordinate plates, the mouse made had a proper positioning in the hand. After producing the mouse prototype model, in order to evaluate the satisfaction and ease of use of it, field research was conducted on the people using it, which resulted in the satisfaction of using the above appropriate mouse and i.e. user-friendly mouse. The degree of satisfaction of the users in using the mouse was determined by the hand palm and its area. Considering the degree of satisfaction achieved by individuals in different groups, it can be concluded that using patterns in nature for the design and creation of the mouse has been successful in the research.

Author Contributions

The manuscript was written through the contribution of all authors. All authors discussed the results, reviewed and approved the final version of the manuscript.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and publication of this article.

Funding

The authors received no financial support for the research, authorship and publication of this article.

References

[1] H. Dicks, The philosophy of biomimicry, *Philosophy and Technology,* 29(3), 2016, 223-243.
[2] J. M. Benyus, *Biomimicry: Innovation inspired by nature*, ed: Morrow New York, 1997.
[3] G. Pohl, and W. Nachtigall, *Biomimetics for Architecture & Design: Nature-Analogies-Technology*, Springer, 2015.
[4] S.C. Burgess, and A.M. King, The application of animal forms in automotive styling, *The Design Journal,* 7(3), 2004, 41-52.
[5] A. Kozlov, H. Chowdhury, I. Mustary, B. Loganathan, and F. Alam, Bio-inspired design: aerodynamics of boxfish, *Procedia Engineering*, 105, 2015, 323-328.
[6] H. Choi, H. Park, W. Sagong, and S.-i. Lee, Biomimetic flow control based on morphological features of living creatures, *Physics of Fluids*, 24(12), 2012, 121302.
[7] M.P. Zari, Biomimetic approaches to architectural design for increased sustainability, *in The SB07 NZ Sustainable Building Conference*, 2007.
[8] Z. Huang, C. Cai, L. Kuai, T. Li, M. Huttula, and W. Cao, Leaf-structure patterning for antireflective and self-cleaning surfaces on Si-based solar cells, *Solar Energy,* 159, 2018, 733-741.
[9] Y. Bar-Cohen and biomimetics, Biomimetics—using nature to inspire human innovation, *Bioinspiration,* 1(1), 2006, P1.
[10] V. Podborschi and M. Vaculenco, Natural Shapes—A Source of Inspiration for Eco-Design, in *Product Engineering*: Springer, 2004, 111-120.
[11] T. Kamps, M. Gralow, G. Schlick, and G. Reinhart, Systematic Biomimetic Part Design for Additive Manufacturing, *Procedia CIRP,* 65, 2017, 259-266.
[12] T. Ikeda, H. Tanaka, R. Yoshimura, R. Noda, T. Fujii, and H. Liu, A robust biomimetic blade design for micro wind turbines, *Renewable Energy,* 125, 2018, 155-165.
[13] N. Hu, P. Feng, and G. Dai, The gift from nature: bio-inspired strategy for developing innovative bridges, *Journal of Bionic Engineering,* 10(4), 2013, 405-414.
[14] P.J. Keir, J.M. Bach, and D. Rempel, Effects of computer mouse design and task on carpal tunnel pressure, *Ergonomics,* 42(10), 1999, 1350-1360.
[15] B. Bamac *et al.*, Influence of the long term use of a computer on median, ulnar and radial sensory nerves in the wrist region, *International Journal of Occupational Medicine Environmental Health,* 27(6), 2014, 1026-1035.
[16] M. Tiric-Campara *et al.*, Occupational overuse syndrome (technological diseases): carpal tunnel syndrome, a mouse shoulder, cervical pain syndrome, *Acta Informatica Medica,* 22(5), 2014, 333.
[17] C. Gaudez and F. Cail, Effects of mouse slant and desktop position on muscular and postural stresses, subject preference and performance in women aged 18–40 years, *Ergonomics,* 59(11), 2016, 1473-1486.
[18] D. Odell and P. Johnson, Evaluation of flat, angled, and vertical computer mice and their effects on wrist posture, pointing performance, and preference, *Work,* 52(2), 2015, 245-253.

[19] K.-W. Lee and Y.-C. Lee, Design and validation of virtually multiple mouse wheels, *International Journal of Industrial Ergonomics,* 40(4), 2010, 392-401.
[20] N. Dehghan, A. Choobineh, M. Razeghi, J. Hasanzadeh, and M. Irandoost, Designing a new computer mouse and evaluating some of its functional parameters, *Journal of Research in Health Sciences,* 14(2), 2013, 132-135.
[21] L.C. Onyebeke, J G. Young, M.B. Trudeau, and J.T. Dennerlein, Effects of forearm and palm supports on the upper extremity during computer mouse use, *Applied Ergonomics,* 45(3), 2014, 564-570.
[22] A.B. Schmid, P.A. Kubler, V. Johnston, and M.W. Coppieters, A vertical mouse and ergonomic mouse pads alter wrist position but do not reduce carpal tunnel pressure in patients with carpal tunnel syndrome, *Applied Ergonomics,* 47, 2015, 151-156.
[23] A. Foorginejad, and K. Khalili, Umbrella curvature: a new curvature estimation method for point clouds, *Procedia Technology,* 12, 2014, 347-352.
[24] A. Foorginejad, and K. Khalili, Automatic Detection of Planes and Cylinders from Point Clouds and Calculation of Their Parameters, *Journal of University of Tabriz Mechanical Engineering,* 46(1), 2016, 89-100, 2016. (in Persian)

ORCID iD

Abolfazl Foorginejad https://orcid.org/0000-0002-4257-9175
Mohammad Lakhi https://orcid.org/0000-0003-3742-3616