Lecture Notes in Mechanical Engineering

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Applications of Computational Methods in Manufacturing and Product Design

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Editors
B. B. V. L. Deepak
Department of Industrial Design
National Institute of Technology Rourkela
Rourkela, Odisha, India

D. R. K. Parhi
Department of Mechanical Engineering
National Institute of Technology Rourkela
Rourkela, Odisha, India

B. B. Biswal
National Institute of Technology Rourkela
Rourkela, Odisha, India

Pankaj C. Jena
Department of Production Engineering
VSS University of Technology
Burla, Odisha, India

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Preface

This book gathers cutting-edge research articles from 2nd Innovative Product Design and Intelligent Manufacturing System (IPDIMS), which will be held at National Institute of Technology Rourkela during 12–13 February 2021. It covers the methods and tools from all research fields of design and manufacturing for the enhancement of the innovation process. This book discusses the current technology issues like design methodologies, Industry 4.0, smart manufacturing, advances in robotics, etc. The contents of this volume are useful to the academicians and professionals working in the research areas—industrial design, mechatronics, robotics, soft computing and automation.

Rourkela, India — B. B. V. L. Deepak
Rourkela, India — D. R. K. Parhi
Rourkela, India — B. B. Biswal
Burla, India — Pankaj C. Jena

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About the Editors

Dr. B. B. V. L. Deepak is currently working at National Institute of Technology, Rourkela as head of the Department of Industrial Design. He received his Master's and Ph.D. degrees from the National Institute of Technology Rourkela in 2010 and 2015, respectively. He has 11 years of research and teaching experience in Manufacturing and Product Design fields. He produced four Ph.D. theses and is currently supervising three Ph.D. scholars. He has published more than 100 papers in various peer-reviewed journals and conferences along with 1 patent. He is also currently handling two sponsored research projects in the field of robotics. He received several national and international awards such as Ganesh Mishra Memorial Award-2019, IEI Young Engineer Award-2018, Early Career Research Award-2017, etc.

Prof. D. R. K. Parhi is working in NIT Rourkela as a Professor (HAG). He is currently heading the Department of Mechanical Engineering. He has received his Ph.D. in Mobile Robotics field from Cardiff School of Engineering, UK. He has 27 years of research and teaching experience in robotics and artificial intelligence fields. He has guided more than 20 Ph.D. theses and published more than 300 papers in various journals and conferences along with three patents. He has completed and currently handling several sponsored research projects in the field of robotics.

Prof. B. B. Biswal is currently acting as Director of National Institute of Technology Meghalaya. He is also a Professor (HAG) in the Department of Industrial Design of NIT Rourkela. He has 33 years of research and teaching experience in FMS, CAD/CAM, robotics fields. He has guided more than 15 Ph.D. theses and published more than 200 papers in various journals and conferences along with 3-patents/copyrights. He has international collaboration with Loughborough University and Slovak University of Technology in Bratislava. He has also completed and currently handling several sponsored research projects in his research field.

Dr. Pankaj C. Jena is currently an Associate Professor at the Department of Production Engineering, Veer Sirendra Sai University of Technology, Burla, Odisha, India. He obtained his B.E. (Mechanical Engineering) and M.Tech. (Mechanical System

Design) from Biju Patnaik University of Technology, Odisha, and Ph.D. (Engineering) from the Jadavpur University, Kolkata. His major areas of research interests include composite material structures, fault diagnosis, fuzzy technique, vibration engineering and use of waste materials in engineering applications. He has published 19 papers in reputed international journals, 15 papers in international conferences, six book chapters and one book. Currently, he is an editorial board member of the *International Journal of Materials Manufacturing Technology*.

Aesthetical Design of a Bio-inspired Futuristic Vehicle for Smart Transportation

Gurmeet Singh and Krishnaraj Ramakrishnan

Abstract Designers need to cultivate storylines and strategies inciting discussions over the key issues of smart and sustainable futuristic transportation. The automotive exterior aesthetics will be of prime importance in the future's individualistic social scenario. With its form and overall personality, vehicle aesthetics needs to respond to the emotional state of the user. Bio-inspiration has been of prime interest in automotive design to meet automobile makers' need to associate their machines with the appeal and capabilities of naturally optimized creatures. The proposed futuristic vehicle's aesthetics has been conceptualized using the technology pull approach of bio-inspiration and the analogy transfer was considered to mimic the biological features and mechanisms of a whale into the aesthetical form of the proposed futuristic vehicle. Blue whales have unique skin pleats that act like human fingerprints to distinguish one creature from the other. This vehicle uses a similar mechanism for its identification and replaces the chassis number system of present-day vehicles. The geometric-organic infused aesthetics of the proposed concept come with a unibody to support the safety and materials needs of future transit. The overall form is cohesive and appeals to users with clean geometric lines blended into the organic body. Upwards-outwards opening doors add to the statement of the user. These doors overlap with the semantics of wings ready to fly.

Keywords Bio-inspiration · Biomimicry · Futuristic vehicle · Automotive styling · Smart transportation

1 Introduction

The aesthetic appeal connects a prospective consumer to a product and leads to the possible purchase of that product. Designers are appreciating the significance

G. Singh (✉)
World University of Design (WUD), Sonepat, India

K. Ramakrishnan
Studio 34, Gurugram, India

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of inducing emotions and communicating product personality to hold users' attention and craft delightful experiences but designing for emotions is not easy as all individuals have their own set of personal experiences and cultured connotations.

People like to show off their sense of style and good taste with their houses, interiors, clothes, and other possessions. Personal vehicles are also a style statement nowadays. Concept cars are dream machines for people as they are stylish, unique, and thrilling to prospective buyers. The appearance is the most significant requirement for a concept car. It must be aesthetically attractive to catch the public's attention. The same aesthetics elicits a sense of pleasure and makes a statement to the users [1]. A study of users' responses toward product newness including trendiness, complexity, and emotion as the product semantics found that the trendiness governs the novelty whereas it has a linear relationship with the preferred aesthetics of the product. The study found that the emotional aspect was largely associated with the curves and wholeness of the product body [2]. Usefulness and usability aspects of a product are heightened with desirable features and aesthetics is the most prominent emotion and desirable feature as a starting touchpoint for purchase of the product. Emotion is the experience that dominates decision-making by commanding attention and creating memory [1].

In the coming decades, the world will see a greater emphasis on resource conservation, energy conservation, town planning, as well as public transport. Congestion and roadblocks are getting complicated, wasting time and business, and adding to the drivers' frustration. The current cities' infrastructure was planned and built years ago and needs reconstruction which is not an easy task [3]. The HIRIKO design team found that private automobiles are the major source of pollution and CO_2 emissions, congesting roads and streets. According to their research, public transport does not cover the entire cities having inconvenient running schedules and thus the first mile and the last mile issue of the transit is getting complicated [4]. The HIRIKO is a compact, folding, two-seat urban electric car which was launched globally in January 2012.

Future transportation is going to be more challenging than ever and bio-inspiration may hold the key to solve its issues. The bio-inspired design establishes nature in the form of inspiration and a guide. It is an iterative methodology applied to many diverse fields. It involves abstraction, search, analysis, comparison, and the transfer of bio-inspired analogies as the core activities of the process [5]. Bio-inspiration is known as biomimicry, biomimetics, biofabrication, and bionics also. Leonardo da Vinci used bio-inspiration as his creativity source and made drawings of many technical machines. The invention of hook-and-loop fastener, Velcro®, is also an example of this phenomenon. "Form follows function" is an industrial design principle and the natural optimization of plants and animals clearly exhibits this. A study showed that the bio-inspired design is efficient in protective structures also. Scholars matched the protection function of the vehicle with fruit peels to introduce the crash-resistant and lightweight design of protective structures [6]. Other research provided an overview of the sharkskin mechanism for drag reduction to enhance the design understanding for efficient surface fabrication with reduced drag force. Fluid engineering finds many applications of sharkskin surface fabrication including swimsuits, golf balls, and

airplanes [7]. The authors proposed a whale optimization algorithm grounded on the bubble-net hunting tactic inspired by the community practice of humpback whales. They found the whale optimization algorithm highly competitive as compared with conventional meta-heuristic algorithms [8].

One more study created analogy categories of architecture, form, function, materials, process, surface, and systems for bio-inspired design with definitions and examples. The form category included visual features such as shape, geometry, and aesthetics [9]. The research into bio-inspired design presents the technology pull and biology push as two main methods of this phenomenon. The technology pull is known as "problem-driven" or "top-down" approach also whereas the biology push is called "solution-driven" or "bottom-up" approach [5].

This research paper presents a new bio-inspired approach using the technology pull method to address the sustainability and last mile issues of futuristic transportation. This work and the methodology can be used to develop a fully functional futuristic vehicle in future studies.

1.1 Bio-inspiration in Automobile Sector

Animals are naturally and efficiently optimized having functional superiority and aesthetical appeal with curves, distinctive forms, and overall cohesiveness. Researchers have studied a boxfish to design an energy-efficient car body and found that the boxfish-inspired car's drag coefficient was much lower than that of a typical passenger car. But the boxfish is not very good looking which limits the bio-inspiration to the hydrodynamics of the body only [10].

Many scholars have studied the use of animal features in car appearance and styling design also. They categorized some of the commercial cars like Peugeot 206, Toyota Previa, Citroën Xsara, Ford Cougar, VW Golf, Renault Megane, Ford Focus, Mazda MX-5, Ford Puma, and Toyota Celica based on their front face design inspired from various shapes of animal eyes [11]. Most of the famous car brands and car models have been named after animals, birds, and even insects as presented in Table 1 [11]. This shows the automobile makers' desire and needs to attract customers by associating their machines with the appeal and capabilities of these creatures.

1.2 Bio-inspired Designs in Other Sectors

The most classical example of bio-inspired design is that of Japan's bullet train inspired by a kingfisher's beak [12]. Another invention is the loop-hook fastener-Velcro® inspired by burrs. A biomechanic by profession, Frank Fish, has developed wind turbines inspired by humpback whales [13]. Climbing gloves from geckos [12], well-ventilated buildings from termite mounds, hydrophobic surfaces from lotus leaves, and responsive facades from plants are other examples of bio-inspired

Table 1 Some of the car brands and models named after animals, birds, and insects

S. No.	Car model	Named after	S. No.	Car model	Named after
1.	Jeep Eagle	Eagle (Bird)	11.	Dodge Viper	Viper (Snake)
2.	Ford Mustang	Horse (Animal)	12.	Buick Skylark	Skylark (Bird)
3.	Ford Puma	Puma (Animal)	13.	Hudson Wasp	Wasp (Insect)
4.	Ford Cougar	Puma (Animal)	14.	Ford Thunderbird	Thunderbird (Mythological Bird)
5.	Ford Falcon	Falcon (Bird)	15.	Lancia Hyena	Hyena (Animal)
6.	Jaguar	Jaguar (Animal)	16.	AC Cobra	Cobra (Snake)
7.	Chevrolet Impala	Impala (Animal)	17.	Triumph Stag	Stag (Animal)
8.	Corvette Stingray	Stingray (Fish)	18.	Volkswagens Beetle	Beetle (Insect)
9.	Sunbeam Tiger	Tiger (Animal)	19.	Peugeot Lion	Lion (Animal)
10.	Renault Spider	Spider (Insect)	20.	Mercury Lynx	Lynx (Animal)

designs [14]. The facades of Esplanade Theater are bio-inspired from the semi-rigid skin of the durian plant. This building's exterior modifies during the day to let sunlight in without overheating the interiors.

2 Futuristic Smart Transportation

We are all naturally interested in the future, including how our own lifestyles may pan out, and how the world might develop over time. Studies showed the scope of "personal mobility" and "co-operative driving" as the new concepts in a rapidly evolving new society. As the living organisms interact with each other in nature, futuristic vehicles will interact with other vehicles, their surroundings, and humans [15].

In the future, we will manage more complex scenarios as road safety, CO_2 emissions, fuel usage, and sustainable public and personal mobility need to be addressed [16]. Futuristic technology will keep the driver out of the loop going beyond the emerging driverless trend. Manually driven vehicles are prone to fatal accidents and this may be the biggest reason for keeping the driver out of the loop. In contrast to this, other researchers have recommended a shared control of technology between the vehicle and the user [17]. An overall system will be developed in future cities to accommodate these smart vehicles to make the human–machine interactions easy, safe, and engaging.

The designers of HIRIKO found that the evolving concept of smart cities will attract 90% of the total population growth. Such cities will be occupied by 60% of the population having a total of 80% share of wealth. The global urban population increased to 47% in 2000 as compared to that of the 13% in 1990. This became 50%

in 2007 with 3.3 billion people being "urban" and will cross the 60% mark in 2030 and 70% mark in 2050 with 9 billion people being urban. This will change the urban settings with a more young and active population [3]. In such a scenario, technology will be everywhere and anywhere with all the devices and even the smart homes connected to the internet. Residents of these cities will seek personal user experience from the products they will be using [4].

2.1 Futuristic Concept Cars and Their Aesthetics

All the recent concept cars of 2019 are electric, showing the commitment toward zero emissions transport of the future. Most of these are built around sustainable, autonomous, and engaging user experience approaches of future transit. These cars are shown in Fig. 1 [18, 19]. The Bentley "EXP 100 GT" envisions a sustainable, autonomous, and electric grand touring by the year 2035. It has options of driving by the user and being driverless. The Mercedes-Benz vision EQS also sticks to green and luxury mobility with the sustainable, elegant, two-toned design and sculptural exterior. Hyundai unveiled the "45 EV" with clean lines and a minimalistic structure having 45° angled exterior in front and back. The AUDI AI: TRAIL Quattro has the ability for automatic driving with excellent outdoor experiences.

DS automobiles developed the DS X E-tense concept supercar with an electric drive embedded in an asymmetric body. Its asymmetric shape is the most user-appealing design feature that keeps the driver out in the wind and the passenger enclosed. Launched in March 2020, the Hyundai Prophecy has a sensuous sporty

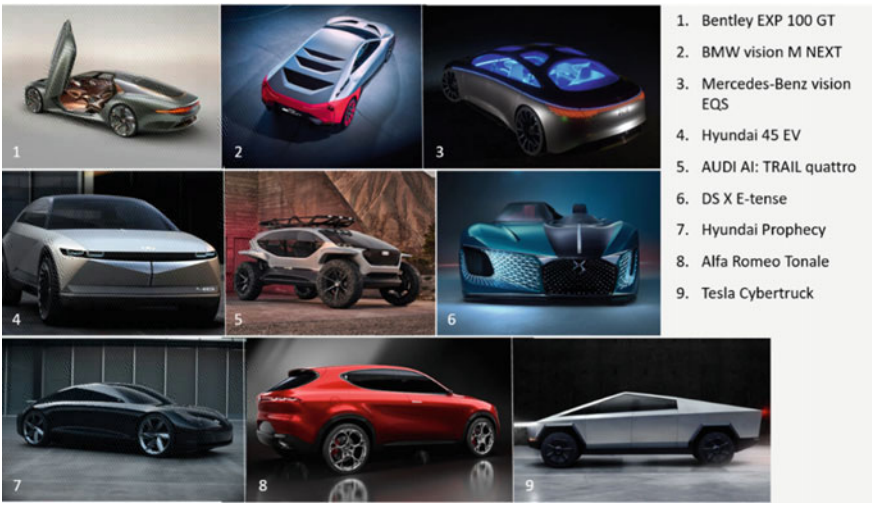

Fig. 1 The most recent futuristic concept cars of 2019–20

design with a voluptuous side section possibly inspired by a perfectly weathered stone. The clean and simple one curve streamline cut ranges from front to rear with a minimalist restriction. The active and sophisticated boat-tail line generated by the rear quarter panels seems to propel the form forward even when it is standing still [18]. The Alfa Romeo Tonale concept presented the electrification feature with the Italian label's exceptional, distinguishing and celebrated styling. Its bold and elegant exterior is enhanced with clean lines and the sculptural front and rear lights. Tesla also launched its Cybertruck, which got a lot of publicity. The design was partially inspired by the lotus esprit sports car that transformed into a submarine in one of the James Bond movies.

Round headlights overlap the grille in the style of their "bower", and the rear is reminiscently sloped in the Bentley EXP 100 GT. Its illuminated matrix grille dominates the view, pairing with the headlamps and flying B mascot to create dramatic and dynamic lighting. The sleek, taut body surfaces are coated in a special silver finish made from a pigment that is a by-product of the rice industry. The design looks complete with spectacular two-meter wide doors that pivot outwards and upwards.

The BMW vision M NEXT has typical sports car proportions inspired by the styling of both classic and contemporary BMWs, such as the "turbo" and "i8". Its low-slung front with strikingly thin headlamps is sharply cut into a wedge-shaped silhouette at the rear. Along the side, the car is defined by smoothly sculpted surfaces as well as gullwing doors. The extended, sophisticated, intense, and dominant one-bow styling of the Mercedes-Benz vision EQS is immediately notable by its two-tone color scheme of silver and dark blue. Its extremely sculptural form comes with a shoulder line—"lightbelt" that encircles the whole car [19]. The most recent futuristic cars of 2019–20 and their main styling features are presented in Table 2.

Table 2 Major exterior styling features of some of the most recent futuristic concept cars

S. No.	Concept car	Major exterior design features
1.	Bentley EXP 100 GT	Outwards-upwards opening doors
2.	BMW vision M NEXT	Gullwing doors
3.	Mercedes-Benz vision EQS	Shoulder line (lightbelt) around the full body
4.	Hyundai 45 EV	Sharp, clean lines with 45° angle cut on front panel
5.	AUDI Futuristic Buggy	Outside view with robust and super-sporty body exteriors
6.	DS X E-tense	Asymmetric compelling body
7.	Hyundai Prophecy	Smooth one cut body exteriors
8.	Alfa Romeo Tonale	Sculptural exterior inspired by human muscular body
9.	Tesla's Cybertruck	Bulletproof geometric minimalistic body

2.2 The Futuristic Scenario and the User Persona

It is wicked to find what kind of mobility and transit should or will be in 2030 or 2050 but designers need to cultivate storylines and strategies inciting discussions over the key issues regarding smart and sustainable futuristic transportation [3]. Machines will be men's friends and he will fall in love with them in the future. Human homes, shopping malls, hospitals, and vehicles will be interconnected with the help of the Internet. Driverless cars may totally disrupt the way they look and feel. The traditional vehicle designs may be objects of the past. The big question is—what will futuristic vehicles look like? Will they be able to fly?

The literature confirms that futuristic smart transport will be based on environmental and economic sustainability to reduce CO_2 emissions and enhance user experience with customized journey experiences. As the roads are congested, the current infrastructure is difficult to rebuild and users are becoming experience-centric; futuristic vehicles' aesthetics and in-journey experiences will be at the core of designers' considerations along with other functional necessities. The smart transportation of the future may have flying cars with highly customizable interiors and exteriors. People will be living alone or with long-distance relationships, with time constraints and internet-connected devices. They will need a companion which they may find in a machine-their personal vehicle. These vehicles may be able to understand the emotional and cognitive state of the user and take the journey accordingly to delight the user. The device interfaces will change drastically and may become completely voice commanded. In this time of full automation and AI, the vehicle aesthetics should be able to convey trust, friendliness, and freshness to the user.

The ideal user persona for future transportation is derived from all the literature reviewed in alignment with the current industry trends synthesized from the careful study of the mentioned concept cars and their exteriors. The user is an individual, working in a private company and living away from family and friends. He wants to go to his job conveniently, avoiding all the road-jam chaos and in a relaxed state of mind. In the evening, he wants to pick up his friend for a coffee. While they are enjoying their coffee, the vehicle should get charged. For all this, he needs a dynamic, fast, friendly, and trustworthy vehicle. The bio-inspired vehicle from whales is an attempt to design such aesthetically pleasing vehicle.

3 Design Process for the Aesthetics of Whale-Inspired Futuristic Vehicle

The technology pull method starts with an identified technical problem and results in a biological inspiration. Whereas the biology push method starts with a known biological solution to be applied in a technical product or problem [5]. The proposed futuristic vehicle's aesthetics has been conceptualized using the technology pull approach of bio-inspiration as presented in Fig. 2.

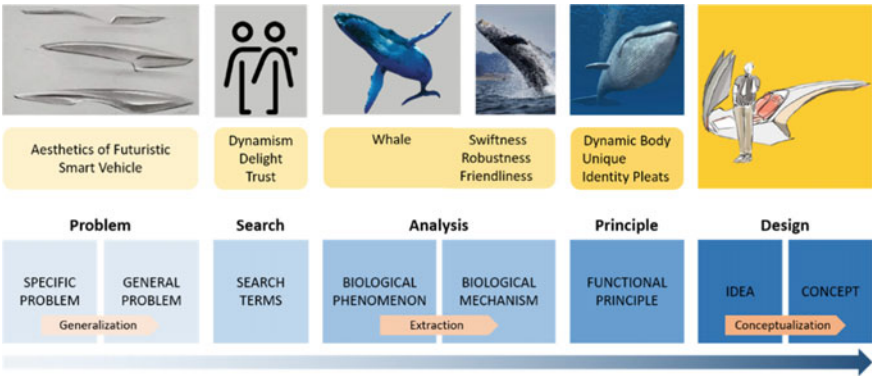

Fig. 2 Design process of a whale-inspired futuristic vehicle aesthetics by the technology pull approach of bio-inspiration framework

3.1 Requirement Analysis and Analogy Transformation for Bio-inspiration

The requirement generation for this futuristic vehicle styling is grounded in three aspects of the future-people and their relationships, cities and their environment along with technology and industries. The users will need an emotional bond, unique identity, and style statement with energy-efficient systems, friendly machines, and appealing aesthetics of the same. The form of the vehicles may be governed by the technologies and materials of that time. The form and body of the solution should support the future manufacturing materials in terms of safety, endurance, and speed as this aspect was the main factor in Tesla's bulletproof Cybertruck. The Cybertruck was designed with an impassable exoskeleton and ultra-hard 30X cold-rolled stainless steel body along with Tesla armor glass [19].

Analogy transfer is considered for mimicking the biological features and mechanisms into the designed solution. In the technology pull method of the bio-inspiration framework, the particular problem is generalized to look for bio-inspiration. In this case, the problem is aesthetics design for futuristic vehicles and the whale is the source of bio-inspiration. Whales have a naturally optimized streamlined fusiform and strong body having limbs modified into flippers to steer. They can conserve the oxygen by reducing their heart rates when staying underwater for long and communicate with melodic sounds even by mimicking human speech. They use various means of communication including fin flapping, tail flapping, breaching, blowing, and ticks. Blue whales have unique skin pleats that act like human fingerprints to distinguish one creature from the other [20]. These pleats expand to accommodate the huge amount of nutrients and food in the water when needed. Despite being such a large body, it is amazing to see the whales moving so easily and swiftly. In some parts of the world, whale watching has emerged as a prominent leisure-cum-adventure activity.

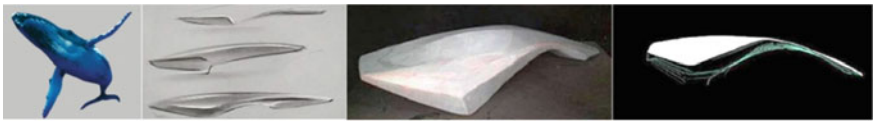

Fig. 3 The whale-inspired futuristic vehicle design phases

3.2 Conceptualization and Modeling

Various forms were drawn based on the analogy transfer from a whale's biological aspects as shown in Table 2. The concept sketch lines illustrated the speed, dynamism, playfulness, and wholeness.

The final result was a new body design inspired by the shape of the whale in considerations with materials, user's emotional bond, and vehicle personality needs of the future transportation system [3, 15, 17]. In spite of being such a large creature, it is impossible to see other creatures that befriend themselves at the first meeting with the man. Whales, like humans, are able to use language, express emotions, and socialize easily. This vehicle has some parts similar to the throat pleats on the bottom of the blue whale's body [20]. These work like its identity and may be considered as an alternate to the present chassis number mechanism for vehicle identification. This vehicle will be able to communicate with the outside world by displaying many colors through these pleats. Further, this mechanism can be utilized to make extra space for the luggage and legs of the passengers.

The overall form is cohesive and appeals to users to induce an emotional bond with the product personality [1] and clean geometric lines blended in an organic body. This form may be manufactured as unibody as per the materials and future transit safety needs. Upwards-outwards opening doors add to the statement of the user. These doors overlap with the semantics of wings to fly. The side view of this vehicle looks ready to fly. This adds the connotation of being on toes the moment you need it. The final 3D modeling and renderings were done using the Autodesk Alias AutoStudio 2016 and Autodesk VRED Design 2016 (Figs. 3 and 4).

4 Discussion and Future Scopes

Futuristic transportation holds many challenges as the roads are getting congested, pollution is rising, transit safety is vulnerable and technology is disrupting the industry [3, 4]. Bio-inspiration may provide reliable solutions for both functional and aesthetical aspects of the futuristic smart transportation system [5]. This futuristic transit concept vehicle is designed for aesthetical aspects and overall exterior form to excite users' emotions for a bond. This form and aesthetics have been conceptualized with an understanding of the futuristic smart transportation scenario [4, 15–17]. For

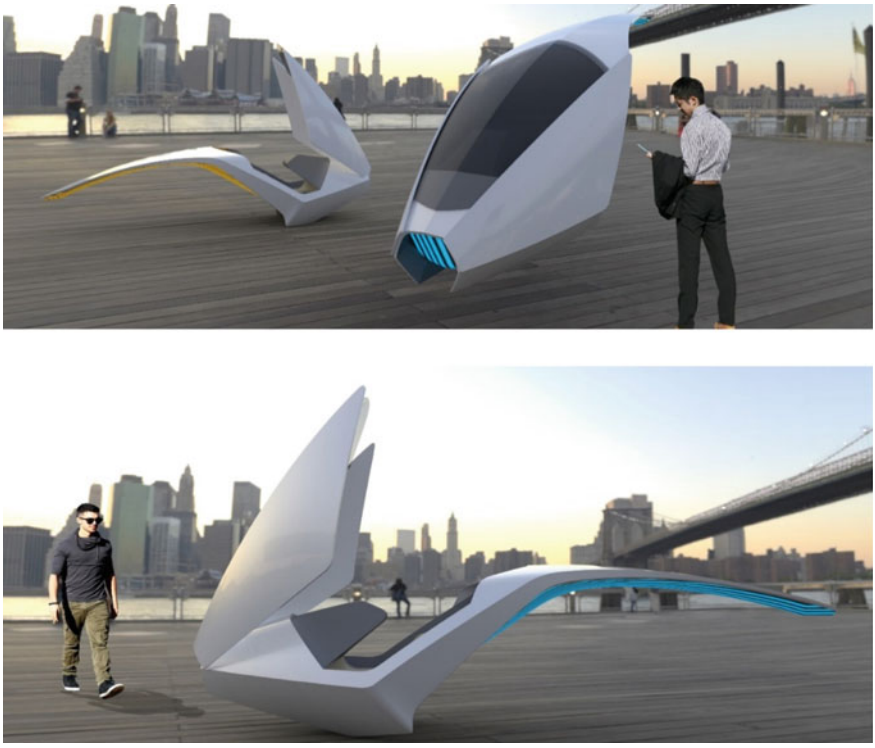

Fig. 4 Final renderings of the whale-inspired futuristic vehicle

the development of functional mechanisms, it needs further research and strategies for a better vision and understanding of technological advancements.

The unibody form with clean geometric lines blended into the organic body is appealing and a style statement for the prospective users of personal vehicles in the future. This vehicle body can be formed using highly reliable and strong cold-rolled stainless steel as that of Tesla Cybertruck [19]. The outwards-upwards opening doors inspired by the whale fins are a delight for anybody looking for style. Whales offer a great source of naturally optimized biological features to use as an inspiration for both functional and aesthetical designs [20]. The same bio-inspiration analogy transfer, as presented in Table 3, can be taken to design the interior and functional elements of this vehicle in future studies.

Previous studies have used the Ask Nature and function-based biologically inspired design methods to design protective structures [6], direct bio-replication, synthetic fabrication, and micro-rolling methods to create a drag reduction surface from sharkskin [7], mathematical modeling of bubble-net feeding behavior of humpback whales for algorithm optimization [8], bio-inspired analogy establishment [9], computational and experimental methods to design a boxfish-inspired energy-efficient car which lacks the user appeal [10] and the application of animal forms in

Table 3 Analogy transfer for the whale-inspired futuristic vehicle aesthetics

S. No.	Biological aspect of a whale	Vehicle aesthetics design aspect
1.	Streamlined fusiform body	Sporty and playful exterior lines
2.	Limbs modified into flippers	Transformable features for turbulent rides
3.	Log out of the water to travel faster	May automatically switch to performance mode for speed increase
4.	Conserves oxygen by slowing down heart rate	Refuel-sense and smart energy saver mode transit
5.	Communicate using melodic sounds and can mimic human speech	Voice operated instructions
6.	Good with teaching, learning and co-operating	AI-powered automated response and behavior
7.	Unique pleats act like fingerprints and expand to accommodate water and food	Vehicle identification provision and expansion for extra space
8.	Naturally optimized for strength and endurance	Efficient and aerodynamic form

automotive styling without any novel contribution in terms of the design of a new form or vehicle [11]. Whereas, the present paper used the technology pull methodology of the bio-inspiration approach along with the analogy transfer methodology for the aesthetical design of a smart futuristic vehicle. These methodologies work better as compared to those used in the previous studies [6–11] to devise a whale-inspired systematic and comprehensive solution for smart futuristic transportation.

5 Conclusion

The challenges of futuristic smart transportation may be met with bio-inspiration as animals and plants have been optimized naturally for performance and sustainability. Concept vehicles also may find many biological features and mechanisms to mimic for appeal and emotional connection with the user. As the prospective personal vehicle owners are projected to be living alone with long-distance relationships, they might find their machines as friends [15]. Their vehicles need to be well developed for their emotional and mobility needs. Thus, the aesthetics and overall personality of such vehicles are very important.

This study has proposed one such vehicle concept with its aesthetics inspired by a whale. As whales are creatures of performance, friendly and trustworthy nature, quest to learn, and a unique personality with their throat pleats, they can help to develop many systems for personal use in the future. The geometric-organic infused aesthetics of this vehicle come with a unibody to support future transit safety needs and materials of endurance. This concept can be further detailed using the same

technology pull method as presented in Table 3 to transfer more of the biological features and mechanisms of whales to enhance the solution.

References

1. Van Gorp T, Adams E (2012) Design for emotion. Elsevier, Amsterdam
2. Hung WK, Chen LL (2012) Effects of novelty and its dimensions on aesthetic preference in product design. Int J Des 6(2):81–90
3. Hickman R, Banister D (2014) Transport, climate change and the city. Routledge, New York
4. HIRIKO. Driving mobility. https://www.un.org/esa/dsd/susdevtopics/sdt_pdfs/meetings2012/statements/espiau.pdf. Accessed 14 May 2020
5. Farzaneh HH, Lindemann U (2018) A practical guide to bio-inspired design. Springer, Berlin
6. Mehta PS, Ocampo JS, Tovar A, Chaudhari P (2016) Bio-inspired design of lightweight and protective structures. SAE technical paper no. 2016-01-0396
7. Chen D, Liu Y, Chen H, Zhang D (2018) Bio-inspired drag reduction surface from sharkskin. Biosurf Biotribol 4(2):39–45
8. Mirjalili S, Lewis A (2016) The whale optimization algorithm. Adv Eng Softw 95:51–67
9. Nagel JK, Schmidt L, Born W (2018) Establishing analogy categories for bio-inspired design. Designs 2(4):47
10. Chowdhury H, Islam R, Hussein M, Zaid M, Loganathan B, Alam F (2019) Design of an energy efficient car by biomimicry of a boxfish. Energy Procedia 160:40–44
11. Burgess SC, King AM (2004) The application of animal forms in automotive styling. Des J 7(3):41–52
12. Fisch M (2017) The nature of biomimicry: toward a novel technological culture. Sci Technol Hum Values 42(5):795–821
13. Goel AK (2015) Biologically inspired design: a new paradigm for AI research on computational sustainability? In: Workshops at the twenty-ninth AAAI conference on artificial intelligence
14. Cohen YH, Reich Y (2016) Biomimetic design method for innovation and sustainability. Springer, Berlin
15. Norman D (2009) The design of future things, Reprint. Basic Books, New York
16. Damiani S, Deregibus E, Andreone L (2009) Driver-vehicle interfaces and interaction: where are they going? Eur Transp Res Rev 1(2):87–96
17. Terken J, Pfleging B (2020) Toward shared control between automated vehicles and users. Automot Innov 3(1):53–61
18. CISION PR Newswire. https://www.prnewswire.com/news-releases/hyundai-motor-unveils-prophecy-concept-ev-301014938.html. Accessed 15 May 2020
19. Designboom. https://www.designboom.com/technology/top-10-concept-cars-of-2019-12-13-2019/. Accessed 14 May 2020
20. Whale. https://en.wikipedia.org/wiki/Whale. Accessed 20 May 2020

Detection and Counting of Nuts and Bolts with Image Processing Using MATLAB

Gunji Bala Murali, Gaikwad Tejas Vasant, Dhananjay D. Kupwade, and Deshmukh Atharva Girish

Abstract Machine vision system plays vital roles in the industrial application in order to maintain quality and control the process. Machine vision technology has numerous applications in various industries like automotive industry, pharmaceutical industries, food and beverage, electronics, packages, and process control. The purpose behind this work is the awareness of machine vision technology and the identification of mechanical components particularly nuts and bolts. An automotive uses nuts and bolts and are assembled at different stages of assembly. The count of these nuts and bolts becomes vital in order to avoid shortage at any stage of assembly. Thus, sorting of the nuts and bolts and their counting is necessary in order to save time. The system can be designed using different algorithms, and all algorithms can be integrated using MATLAB software.

Keywords Machine vision · MATLAB · Nuts bolts counting · Image processing technique

1 Introduction

Image processing techniques play crucial role in extraction of information from the image. The image processing technique can be applied almost all the fields like surveillance, face tracking, defect identification, counting size sorting, and many more. The applications of image processing techniques are enormously increased in

G. B. Murali (✉) · G. T. Vasant · D. D. Kupwade · D. A. Girish
Vellore Institute of Technology, Vellore, Tamil Nadu 632014, India
e-mail: balamurali.g@vit.ac.in

G. T. Vasant
e-mail: gaikwadtejas.vasant2019@vitstudent.ac.in

D. D. Kupwade
e-mail: dhananjay.dattatray2019@vitstudent.ac.in

D. A. Girish
e-mail: atharvagirish.deshmuh2019@vitstudent.ac.in

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the field mechanical engineering. Sathiyamoorthy has explained various software's like Lab VIEW, MV Impact, OpenCV, and MATLAB in applying digital image processing technique for obtaining required information from an acquired image [1].

Jian et al. apply machine vision system to identify the shaft diameter is within the permissible range. In the algorithm, the authors classify the components as OK, Not OK, over size, and under size based on the measured diameter [2]. Zhang et al. have done the similar work using edge detection algorithm. The images are processed by the Lab VIEW software, and the output is displayed on the monitor. The algorithm works on counting the number of pixels along the edge of the shaft; by counting the number of pixels, the pixel range is calculated and compared with the acceptance range of pixels value to qualify the shaft [3].

Cheng and Jafari proposed vision-based system to control the damage of the top die for punch press machine. In this system, a camera is placed in such a way to see the upper die weather component is attached in the top die or not. If the component is attached in the top die, pneumatic actuator is used to lock the pedal [4]. Fernandes et al. suggested vision-based method for blister pack inspection for identifying the tablets in the packets. From the proposed system, the patient can identify whether the blister pack consist of tablet or not, which will be helpful to the patients in emergency conditions [5]. Hsu et al. worked on development of vision system to identify the level of the liquid in the bottle and the presence of cap for the bottle. From the designed system, the algorithm can easily identify the presence of cap and level of liquid in the bottle [6]. Amit et al. implemented image processing technique to identify the size of nuts and bolts. In the developed system, artificial neural network is used to train the dataset for identifying the size of nut and bolts [7]. Priya et al. proposed mathematical morphology approach to identify the defects for the fabrics using image processing technique. In the research article, the authors used concept of converting the images to the bit planes, by which defect portion on the fabric can be identified [8].

Karimi and Asemani have written a review article in the area of defect identification on tiles using image processing techniques. In the review article, the authors elaborated different kinds of image processing algorithms like wavelet transform, filtering, morphology and contourlet transform, and their performance comparison on defect identification for tiles [9]. Karimi et al. have proposed vision system to identify defects on rail surfaces. The authors used spectral image differencing procedure (SIDP) to identify defects like flakes, cracks, grooves, or break-offs on rail surfaces [10].

Keeping in mind the numerous advantages with the vision system, in this research article, image processing and enhancement techniques are implemented using MATLAB to identify and count the nuts and bolts. The developed code is tested with different sort of images consisting of nuts and bolts, and the results obtained are satisfactory, and the algorithm identifies the nuts and bolts with 90% accuracy. In this research article, a simple method using MATLAB to identify the

shape of the object is proposed, which doesn't require any sort of training the algorithms like in ANN or CNN to sort the object, which is the novelty of the present work.

2 Proposed Methodology

In automotive industries, the assembly of a vehicle uses nuts and bolts in huge quantity. It is important that at the time of assembly, the pairs of nut and bolt should be available in appropriate number in order to optimize the assembly time. To detect and count the nuts and bolts, MATLAB platform is used with suitable feature extraction algorithm. Study different algorithms for detection on nuts and bolts. Optimize the assembly time. The workflow may be stated as per Fig. 1 shown. Starting from the preparatory stage, deciding the area of the work project planning is done. Several research papers were studied as of the literature review is concerned. Logical design is developed as per the application. The MATLAB code was developed for the recognition and measurement of nuts and bolts. The images of nuts and bolts ran through the code, and the results were obtained.

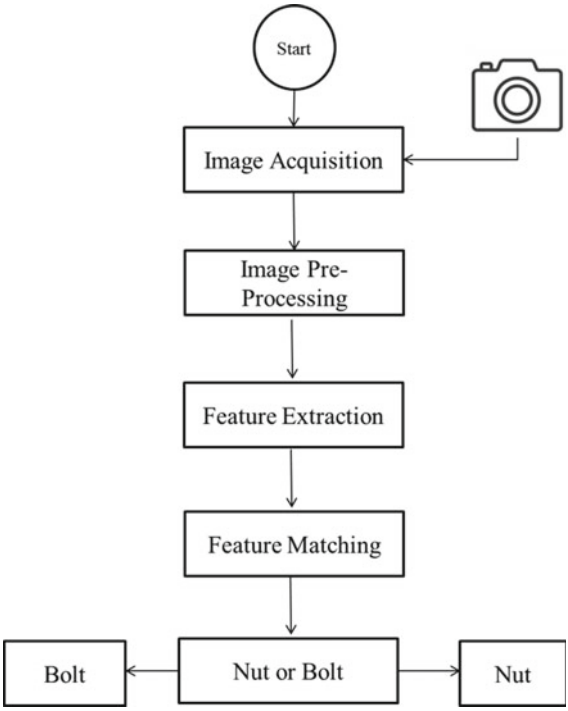

Fig. 1 Proposed methodology

Image acquisition can be achieved by means of different cameras available in the market. For the testing purpose, mobile phone camera or laptop camera can be utilized. After the image acquisition, the image will be preprocessed in order to make it suitable and feasible for the further process. Thereafter, feature extraction is done. The feature extraction will distinguish nuts and bolts. The program detects nuts based on its circular feature; and by subtracting the number of nuts, the number of bolts is measured. The nuts and bolts are differentiated as the nut is component which is having hole, and bolt is component which is having length. The proposed methodology for identifying and counting the nuts and bolts is shown in Fig. 1.

The system proposed can be roughly demonstrated as shown in Fig. 2. The image acquisition is done by the camera installed over the conveyor. The image is the preprocessed by the preprocessor. The data are then sent to the classifier. Afterward, the decision is made, and nuts and bolts are identified and counted.

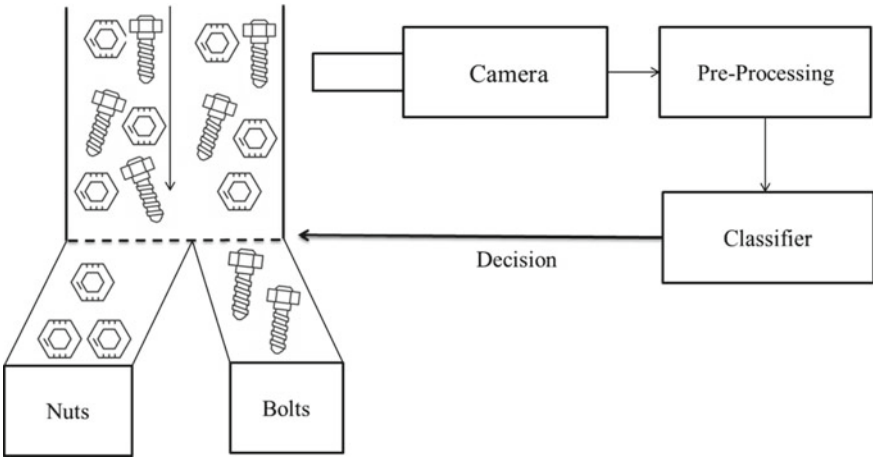

Fig. 2 Line diagram of machine vision system