Prospects of Intuitive Interaction Modeling in Automated Shape Generation

Jonas Žukas\textsuperscript{1*}, Kostas Gaitanži\textsuperscript{2}, Darius Zabulionis\textsuperscript{1}

\textsuperscript{1} Vilnius Tech, Vilnius, Lithuania
\textsuperscript{2} European Humanities University, Vilnius, Lithuania

Received 2021-09-09; accepted 2022-02-02

Abstract

In this article, authors discuss new possibilities for the spatial design universal aesthetic development. Creative artistic means are conditioned by the human ability to comprehend and interpret objects in a particular context. Ideas of arts and science coexistence have been relevant since antiquity. The 20th century, especially the Bauhaus movement, gave a rational basis for conjoining artistic inspiration with the parametric constraints. Contemporary digital technologies provide new possibilities to enhance human creative potential by employing scientific methods. In search of material environment evaluation reference points, it is important to establish a robust connection of human mind and physical world. Subjectivity and intersubjectivity of experiences raise issues in human perception studies, involving both phenomenal and material processes. Embodied cognition reveals itself as an intuitive experience or discovery which provides a new perspective for the creative application. The authors aim to investigate the creative opportunities of automated shape generation systems. The main issue is to find a universal application of creative process analysis. Parametric constraints offer the opportunity to use statistical tools in art practice. These constraints are based on embodied cognition capabilities. Combined methods of qualitative and quantitative evaluation help to assess the contextual relevance of the object and to determine the cultural and pragmatic effectiveness of automated design solutions. The study offers theoretical and applied cross-disciplinary research direction to discover new creative means in material environment design, including architecture and urban planning.

Introduction

Intuitive design studies have shown the lack of the universal design methodologies that exploit the principles of intuitive cognition \cite{1}, \cite{2}. This paper explores practical possibilities of integrating intuitive design principles into automated shape generation systems. The conceptualization of design as communication has proven to be a valuable approach for research and practice, since it provides designers with a perspective on product conceptual links and how they are experienced by the users \cite{3}. Investigation in modern product design reveals the importance of implicit knowledge and everyday human experiences in creating a more intuitive design \cite{4}. Subjective opinions are the key objects of good design discussion, hence automated shape modeling processes and design constraints provide opportunities to validate design solutions. The main issue is the formation of human connection with technology. Human ideas and creativity are not recognizable by machine or artificial intelligence, so the challenge is how to combine the best qualities of these agents without undermining the essential quality criteria. It is important to answer the question of how automated design is assessed in practice and conceptually, whether it is a tool or an assistant, or perhaps an independent actor.
Since the 1970s, the new media, which do not require direct hand touch, have attracted much more attention from the public. Traditional artistic practices involve the union between consciousness and the bodily experience (in philosophy it is usually perceived as a 'qualia') in order to change the environment's conceptual and material properties. This attitude provides an opportunity for the further study of human and environment connections. The application of design thinking methods in automated design processes is a highly innovative field of research [5]. The studies performed on a parametric design application create preconditions for the integration of design constraints into parametric, generative or other shape modeling tasks [6], [7]. The integration of intuitively perceivable content to the automated design processes requires the introduction of new design stages to set the creative constraints. The object of this study is the process of design thinking. The aim of the paper is to reveal new interdisciplinary opportunities to model intuitive content and to integrate quantitative research methods into the art practice to assess and improve the quality of the material environment. The tasks of this paper are to evaluate the issues of automated design intuitive perception and to offer new scientific and artistic directions for the evaluation of its quality. Combining advanced spatial modeling techniques would underpin the applied methodical capabilities to model the shape's intuitive content. It is expected that the results of the research will provide data to support the development of a universal shape modeling tool to create new spatial expressions. The implementation of this approach does not deny the importance of the author but offers less constrained and specific (limited to professional knowledge) creative tools. The scientific application of this approach creates cross-disciplinary opportunities to study and adapt automated design processes for the universal integration of design constraints.

I. Research Context

Material environment quality depends on a successful reflection of contemporary cultural values in a particular society. In the multicultural world, it is becoming increasingly difficult to provide objects of cultural significance in the local communities, referring to the key role of contemporary social and cultural sustainability [8]. To ensure material environment sustainability and optimize communication means, the relationship between the new values within a particular space must be clarified at all levels of interaction. Urban planning, design, and art create dynamic systems that question and complement each other [9]. The harmony of the material environment is inseparable from the aesthetic feeling, which is directly influenced by the intuitiveness of the object [10], [11], [12]. Intuitive cognition is an essential participant in the creative process and evaluation, which involves all aspects of environmental manifestations [13]. The process of intuition occurs when the individuals encounter clues, which need to be quickly understood to obtain solutions to the complex problems in dynamic situations [14]. In terms of situation assessment, the limbic system has evolved from the need to avoid mistakes as a means to increase survival chances. Stimuli are judged from a position of potentially negative (primarily somatic markers act as 'alarm') and positive outcome. Somatic markers ensure 'early warning' and emphasize any potential adverse effects of a particular choice [15], [16]. In the case of intuitive theory in psychology, beliefs, desires and actions are linked by the rational action principle – the individual will try to fulfill his desires in the most efficient way possible, taking into account his beliefs about the world [17], [18]. Human intuitive interaction with the environment is profoundly influenced by the embodied cognition [19], which allows to explore, modify and simulate human choices/actions in the given environmental conditions. The agent is looking for the most efficient way to interact with the surroundings, and embodied cognition gives the notion of possible action affordance [20].

Problems of 'embodiment' and 'embodied experience' are closely related with the so-called 'hard problem of consciousness' or relation between physical processes in the human nervous system and phenomenal experiences [21]. While the 'explanatory gap' of experiences still exists [22], with no final consensus among philosophers and neuroscientists, Metzinger's model of consciousness as 'phenomenal self' proposes the most relevant solutions to this moment [23]. Metzinger describes consciousness as a 'transparent avatar', a byproduct of cognitive brain activity. 'Transparency' means that 'self-model' cannot perceive itself as a 'model' and is illusively convinced of his 'authenticity'. For this reason, consciousness cannot be investigated as a natural phenomenon. Cases of people creating in an unconscious mental state have been described, but these reports have not been scientifically validated [24]. Despite the fact that the question of whether unconscious visual creation is possible remains open. Artistic creation is rightly associated with a first-person perspective, speaking from a subjective point of individual consciousness placed in the world of phenomenon. On the other hand, the aesthetic values are something that exists in the intersubjective field, and therefore in itself demand third-party assessment. An artist cannot detach himself from subjectivity, as a scientist aspires, but he can combine the perspectives of the first and third person. Recent work on the development of artificial intelligence systems, based on artificial neural networks, provides strong evidence in favour of a 'mysterianist' approach to the embodiment process [25] that denies the possibility to resolve the nature of the body-consciousness relationship. It also follows that without clear criteria to
define the boundaries of an object’s interactivity, we fall into a situation of contradiction because it is difficult not to construct a demarcation between the subject’s abilities and the object’s content. Examining the problem of ‘embodiment’, Metzinger introduces the concept of minimal phenomenal self (MPS) – a ‘self-model’ detached from any bodily experience [26]. Usually, the functioning of self includes various bodily experiences, becoming a base for any kind of conceptual metaphors [27], essential for any verbal or visual language. At the same time, self can expand to the objects out of the individual physical body, for example, in the notorious ‘rubber hand’ experiment [28]. In a very similar way, consciousness can expand into certain external objects – tools, artifacts, vehicles, treating them as part of the ‘body’. Such expansion is a kinesthetic sense, which is often necessary for the successful interaction with the environment. For instance, an experienced driver unconsciously perceives a car as part of his body. It is important to note that such self-expansion usually occurs on an intuitive level, independently of conscious processes. In such a case, the good example of material environment design allows this process to take place easily and smoothly, which undoubtedly affects the level of user’s satisfaction with an object/environment.

In this article, the intuitive interaction is considered as a human ability to comprehend physical causality [29], [30]. Efficiency in communication can be optimized by using behavioural patterns, suggestive interaction or using mechanical dissemination principles. The analysis of scientific sources reveals that the cross-disciplinary research provides the basis to discover methods for aesthetic shape analysis, modeling and evaluation. By combining art with science, a method of aesthetic shape modeling exploits cognitive abilities and the causality of the environment. The author’s previous research has confirmed that the human ability to comprehend Newtonian physics is embodied into cognition and allows us to intuitively perceive and anticipate the interaction with the environment [31]. It can be concluded that the principles of intuitive cognition can be directly applied in creative processes.

Not all material environment objects are easily expressed via visual language due to the structure of the human cognitive mechanism. The conceptual human imagination can operate on non-visualized objects [32]. Various methods of visual decomposition can be used as a means of conveying such narratives by artistic language, expanding the user’s cognitive abilities. Also, a promising path is the use of technologies ‘beyond cognition’ in combination with traditional artistic practices. Interaction with the material environment is conditioned by the constitution of intuition and embodiment. The effective design of the material environment should take into account the specifics and limitations of human perception. Over the last ten years, the progress in artificial neural networks research has opened up completely new opportunities [33]. The process of image recognition, generation and transformation is stochastic in nature, hence the final result can only be predicted. Another important aspect of this system is the use of evolutionary machine learning algorithms. The paradox is that these systems are created by a man, but a man is no longer able to comprehend how exactly they work [34]. The crucial moment is the use of digital graphics technology aimed at controlling markers of personal psychophysiological limitations (hand shake, sensitivity, pressure, etc.). Combining embodied cognition limitations with an automated shape generative system offers new methodological insights in design thinking processes. This approach has a universal application in intuitive design methodology. Modeling constraints can be used to optimize the aesthetic and functional quality of an object.

II. Methodology

In line with the existing consensus that humans are conscious beings, it must be acknowledged that the depiction of one or another object is a conscious activity [35]. The process of artistic creativity is influenced by the embodiment of conscious self. An image taken by a self-operating camera can be processed by a relatively simple algorithm and transferred to a device that will create a depiction of the object. All this process requires neither the buds of consciousness nor the beginnings of intellect. Still, it is a direct capture of an existing image, which is fundamentally different from drawing from memory or imagination. The word ‘memory’ is used here to express human memory, unlike the ‘memory’ of a computer. Human memory is directly related to the ability to create counterfactual situations and objects never existed before (i.e., imagination) [29].

In this study, it is important that inherent human abilities such as imagination can be successfully conjoined with the machine learning process. Parametric design allows the exploitation of human creativity to define the initial design constraints [7]. The process in itself is autonomous, and the outcome is unknown. As a case study, an important contribution to the research field is the development of methodology for grammatical evolution and the definition of representation for the certain architectural spaces coding [5]. This work examines the potential of automated processes to generate simple boxes – the external building envelope and combine architectural box shapes with the complex shapes of the facade elements. This study presents a method of grammatical evolution based on genetic programming for the automated shape modeling. Three experiments of two types of shape generation are presented: architectural box design and facade design, respectively. This study demonstrated the applicability.
of the evolutionary approach to facilitate the early stage of architectural design. It is concluded that automatic shape generation in the evolution of grammar offers tremendous opportunities to create performance-based creative systems. In the presented experimental phase, the representation of architectural shapes is independent of context and environment, which would normally influence architectural design solutions. It may also lead to the formation of functional constraints based on cost, area, volume, or other geometric and functional properties. Application of parametric design principles in architecture allows to define and apply data in a fractal manner (Fig. 1). Embodied design can be used in a material environment from the smallest scale (hand) to the largest (human group) in urbanism.

A relevant aspect in the search for more effective design methods is to reduce the amount of the design stages and to objectify design processes. It has been found that it is possible to develop new intuitive design methods that can be used universally in the material environment development [36]. Evaluation of aesthetic shape is inseparable from its function, which determines the shape input arguments (control shape) and limitations of experimental modeling. Authors propose such shape conceptualization steps [31]:

1. Set limits for correct interaction with the element.
2. Determine the location and direction of the interaction.
3. Explain the peculiarities of the correct interaction and collect data (anthropometric or other).
4. Describe and explain human mechanical interaction with the element by visual schemes.
5. Interpret data conceptually and visually.

Application of visual shape decomposition methods to the aesthetic shape monitoring, modeling and evaluation, reduces the number of elements, as a result visual complexity. Shape decomposition techniques and evaluation conditions are important initial constraints that determine perception quality and amount of information needed to reflect the modification. Many studies have been done to formalize the object's shape decomposition and evaluation process [37], [38], [39], [40], [41]. Decomposition of the 3D shape to represent it in a 2D media is relevant because of the issues arising due to the complexity of 3D shape position and view angles and, as a result, allows to reduce the information noise. The established methods of shape conditioning, modeling and experimental techniques enable the creation of conceptual models and monitoring of intuitive interaction effectiveness.

Evaluation of the object must include its context and function. Applied functional and interaction analysis allows defining pragmatic value criteria. By combining investigation methods, it is possible to examine the object in terms of utilitarian and cultural indicators. In his dissertation, Žukas proposed stages for the experimental shape monitoring [31]:

- Establish experimental observation conditions (context) for the particular object.
- Perform monitoring of the object's shape value and determine points of functional significance.
- Determine interaction mechanical causality and integrate embodied impressions into the object's design frame.
- Evaluate conceptual shape models in terms of intuitive interaction effectiveness using qualitative and quantitative methods.

The author determined that the shape which reveals the method of use and universally harmonizes the intuitive interaction. The criteria for the shape evaluation were also established as the ability to reveal the method of use and the acceptability of the shape's aesthetic quality. Based on these two criteria, it is possible to investigate the pragmatic and cultural value. An intuitive shape harmonization variable was implemented into the box design to reveal the method of use. This impression can be attributed to the object's function – to open the lid of the box and human interaction peculiarities. The aim of the experiment is to test the possibility to model and evaluate intuitive interaction effectiveness using observation methods to obtain quantitative data. In this case, the intuitive interaction effectiveness criteria are the number of attempts to open the box. The fewer attempts – the better the shape effectiveness. The results strongly support intuitive harmonization methodology to complement the object function and to teach interaction. To test the variable's ability to improve the aesthetics of an object, experiment participants were asked to rank the same shapes' appeal using the MaxDiff qualitative evaluation method. It has been found that this method is suitable for investigating intuitive reactions to aesthetics as information is evaluated while avoiding deliberate consideration [42]. This experiment opened an opportunity

Figure 1. Human embodied cognition and material environment scale relation [authors].
to correlate utilitarian qualities with the aesthetic ones. The results confirmed that shape, which complements function, improves aesthetics as well.

The quantitative investigation requires clear criteria according to which the design object effectiveness is tested. The criteria can be defined according to the function of the object/space, which can be enhanced at the same time improving aesthetic value. By combining qualitative and quantitative research methods, it is possible to assess aesthetic and pragmatic values and monitor their interrelation.

III. Findings

Interdisciplinary approach to research reveals the opportunities for the quantitative evaluation of the design result effectiveness. In connection with the object design, the value of parameters facilitating the embodiment process is important. Given that the process of embodiment can be reflected (in everyday practice it usually takes place intuitively), it can be quantified through intuitive design research. The questionnaire, which allows the evaluation of the product’s intuitive user-friendliness, also reveals the smoothness of the embodiment process and provides valuable information about the correlation between physical reality and mental experience. In quantitative investigation, the analysis of the object’s function provides criteria that allows to assess the objective and pragmatic effects of shape harmonization. To examine intuitive effectiveness, various criteria or sets of the criteria, such as time, distance, amount of force, number of attempts, etc., can be employed.

It can be concluded that this methodological approach allows to effectively introduce the embodied design capabilities to reflect human values in an automated parametric design process. This method creates an independent design tool and can be introduced as a part of the conceptual content.

Conclusions

Given that art and visual design perform primarily a communicative function, the creator must pay attention to how the addressee can read the message. It can be concluded that the author should create a certain mental model for the user. This model must also include the totality of the user’s unconscious mental processes. In this context, anticipating the intuitive reactions to the material environment object becomes crucial. The artistic application of the proposed intuitive interaction investigation will allow a more efficient and dynamic isolation of shape variables, providing quantitative data within the framework of artistic concept. It will allow improving communication means and measuring their effects on a conceptual basis. The creator defines the content aims; hence this tool allows not only to measure the impact of the artwork but gives an inherent content element.

In today’s context, cultural acceptability problems have become particularly acute, since many opinions must coexist in a public space. The proposed artistic means provide an opportunity to create aesthetic content without the use of symbolic language, which depends on particular knowledge, thus responding to the needs of modern society. The development of new shape modeling methods and their application, invoking interdisciplinary knowledge, will provide advanced opportunities for the spatial design research. Further studies should experimentally explore the applied methods for integrating intuitive design principles into automated shape generation systems.

Authors’ remark: Some parts of this article are published in the PhD Thesis “Harmonisation of an aesthetic shape from the perspective of intuitive cognition” by J. Žukas.

REFERENCES

1. Hurtienne, J., Klöckner, K., Diefenbach, S., Nass, C., Maier, A. Designing with image schemas: resolving the tension between innovation, inclusion and intuitive use. *Interacting with Computers*, vol. 27, no. 3, 2015, pp. 235–255. https://doi.org/10.1093/iwc/iwu049
2. O’Brien, M., Rogers, W., Fisk, A. Developing an Organizational Model for Intuitive Design. Technical report HFA-TR-1001. Atlanta, GA: Georgia Institute of Technology, 2010. 133 p.
3. Crilly, N., Maier, A. M., Clarkson, P. J. Representing artefacts as media: Modelling the relationship between designer intent and consumer experience. *International Journal of Design*, vol. 2, no. 3, 2008, pp. 15–27.
4. Blackler, A., Hurtienne, J. Towards a unified view of intuitive interaction: definitions, models and tools across the world. *MMI Interaktiv*, vol. 13, 2007, pp. 36–54. https://eprints.qut.edu.au/19116/
5. Muehlbauer, M., Burry, J., Song, A. Automated shape design by grammatical evolution. *International Conference on Evolutionary and Biologically Inspired Music and Art, EvoMUSART 2017*: Computational Intelligence in Music, Sound, Art and Design, 2017, pp. 217–229. https://doi.org/10.1007/978-3-319-55750-2_15
6. Liu, K., Zeng, X., Wang, J., Tao, X., Xu, J., Jiang, X., Ren, J., Kamalha, E., Agrawal, T. K., Bruniaux, P. Parametric design of garment flat based on body dimension. *International Journal of Industrial Ergonomics*, vol. 65, 2018, pp. 46–59. https://doi.org/10.1016/j.ergon.2018.01.013
7. Alcaide-Marzal, J., Diego-Mas, J.A., Acosta-Zazueta, G. A 3D shape generative method for aesthetic product design. *Design Studies*, vol. 66, 2020, pp. 144–176. https://doi.org/10.1016/j.destud.2019.11.003
8. Preiser, W. F. E., Smith, K. H. Universal design at the urban scale. In W. F. E. Preiser and K. H. Smith eds., *Universal Design Handbook*, New York: McGraw-Hill Education, 2010, pp. 20.1–20.8.
9. Cartiere, C., Willis, S. *The Practice of Public Art*. London: Routledge, 2008. 288 p.
10. Humphries, T. Considering Intuition in the Context of Design, and of Psychology. WIRAD’s 2nd Emerging Researchers Symposium May 2012, Cardiff School of Art and Design, Cardiff Metropolitan University, Wales, 2012. 10 p.
11. Hodgkinson, G., Langan-Fox, J., Sadler-Smith, E. Intuition: A fundamental bridging construct in the behavioural sciences. *British Journal of Psychology*, vol. 99, no. 1, 2008, pp. 1–27. https://doi.org/10.1348/000712607X216666
12. Mortensen, D. How to Create an Intuitive Design, 2017 [online]. The interaction Design Foundation [cited 07.07.2021]. https://www.interaction-design.org/literature/article/how-to-create-an-intuitive-design.
13. Harte, R., Glynn, L., Rodriguez-Moliner, A., Baker, P. M., Scharf, T., Quinlan, L. R., O’Laughlin, G. A Human-Centered Design Methodology to Enhance the Usability, Human Factors, and User Experience of Connected Health Systems: A Three-Phase Methodology. *JMIR Human Factors*, vol. 4, no. 1, 2017, pp. E8. https://doi.org/10.2196/humanfactors.5443
14. Klein, G. *Sources of power: How people make decisions*. Cambridge: MIT Press, 1998. 352 p.
15. Le Doux, J. E. *The emotional brain: The mysterious underpinnings of emotional life*. New York: Simon and Schuster, 1996. 384 p.
16. Damasio, A. R. *The feeling of what happens: Body, emotion and the making of consciousness*. London: Vintage, 1999. 400 p.
17. Baker, C. L., Saxe, R., Tenenbaum, J. B. Action understanding as inverse planning. *Cognition*, vol. 113, no.3, 2009, pp. 329–349. https://doi.org/10.1016/j.cognition.2009.07.005
18. Wellman, H. M. *The Child’s Theory of Mind*. Cambridge, MA: The MIT Press, 1992. 358 p.
19. Glenberg, A., Havas, D., Becker, R. Rinck, M. Grounding Language in Bodily States: The Case for Emotion. In D. Pecher and R. A. Zwaan eds., *Grounding cognition: The role of perception and action in memory, language, and thinking*. Cambridge: Cambridge University press, 2010, pp. 115–128. https://doi.org/10.1017/CBO9780511499968.006
20. Gibson, J. J. *The perception of the visual world*. Cambridge: The Riverside press, 1950.
21. Chalmers, D. *The Conscious Mind. In Search of a Fundamental Theory*. New York: Oxford University Press, 1996. 433 p.
22. Levine, J. Materialism and Qualia: the Explanatory Gap. *Pacific Philosophical Quarterly*, vol. 64, 1983, pp. 354–361.
23. Metzinger, T. *Being No One. The Self-Model Theory of Subjectivity*. Cambridge: MIT Press, 2003. 714 p.
24. Chatterjee, A. The neuropsychology of visual artists. *Neuropsychologia*, vol. 42, no. 11, 2004, pp. 1568-1583. https://doi.org/10.1016/j.neuropsychologia.2004.03.011
25. Silver, D., Hubert, T., Schrittwieser, J., Antonoglou, I., Lai, M., Guez, A., Lanctot, M., Sifre, L., Kumaran, D., Graepel, T., Lillicrap, T. Mastering chess and shogi by self-play with a general reinforcement learning algorithm, 2017 [online]. *Cornell University* [cited 07.07.2021]. https://arxiv.org/abs/1712.01815
26. Metzinger, T. *The Ego Tunnel: The Science of the Mind and the Myth of the Self*. New York: Basic Books, 2009. 291 p.
27. Lachow, G., Johnson, M. *Metaphors We Live By*. Chicago: University of Chicago Press, 1980. 333 p.
28. Ehrens, H. H. the experimental induction of out-of-body experiences. *Science*, vol. 317, no. 5841, 2007, pp.1048–1048. https://doi.org/10.1126/science.1142175
29. Gerstenberg, T., Tenenbaum, J. Intuitive Theories. In M. R. Waldman ed., *The Oxford Handbook of Causal Reasoning*, Oxford: Oxford University Press, 2017, pp. 515–548. https://doi.org/10.1093/oxfordhb/9780199399550.013.28
30. Battaglia, P. W., Hamrick, J. B., Tenenbaum, J. B. Simulation as an engine of physical scene understanding. *Proceedings of the National Academy of Sciences*, vol. 110, no. 45, 2013, pp. 18327–18332. https://doi.org/10.1073/pnas.1305672110
31. Žukas, J. *Harmonisation of an aesthetic shape from the perspective of intuitive cognition*. Dissertation, Vilnius tech, 2021. https://doi.org/10.20334/2021-031-M
32. Harman, G. *On the Horror of Phenomenology: Lovecraft and Husserl*. In R. Mackay ed., *Collapse IV: Philosophical research and development*, 2008, pp. 333–364.
33. Silver, D., Schrittwieser, J., Simonyan, K., Antonoglou, I., Huang, A., Guez, A., Hubert, T., Baker, L., Lai, M., Bolton, A., Chen, Y. Mastering the game of go without human knowledge. *Nature*, vol. 550, 2017, pp. 354–359. https://doi.org/10.1038/nature24270
34. McGinn, C. *Basic Structures of Reality: Essays in Meta-Physics*. Oxford: Oxford University Press, 2011. 256 p.
35. Shepherd, S. Perception: Exploring Cognition and Consciousness Through Visual Art. *Mahurin Honors College Capstone Experience / Thesis Projects*, paper 819, 2019 [cited 07.07.2021]. https://digitalcommons.wku.edu/stu_hon_theses/819
36. Žukas, J. Experimental harmonization of shape intuitive interaction. *Architecture and Urban Planning*, vol. 16, no. 1, 2020, pp. 72–77. https://doi.org/10.2478/auap-2020-0011
37. Dotson, J. P., Beltramo, M. A., Feit, E. M., Smith, R. C. *Modeling the Effect of Images on Product Choices*, 2019. https://doi.org/10.2139/ssrn.2282570
38. Kang, N., Ren, Y. Feinberg, F. M., Papalambros, P. *Form+Function: Optimizing Aesthetic Product Design via Adaptive, Geometrized Preference Elicitation*. University of Michigan, 2016. 71 p.
39. Kreuzbauer, R., Malter, A. J. *Embodied cognition and new product design: Changing product form to influence brand categorization*. *Journal of Product Innovation Management*, vol. 22, no. 2, 2005, pp. 165–176. https://doi.org/10.1111/j.0737-6782.2005.00112.x
40. Ranscombe, C., Hicks, B., Mullineux, G., Singh, B. Visually decomposing vehicle images: Exploring the influence of different aesthetic features on consumer perception of brand. *Design Studies*, vol. 33, no. 4, 2012, pp. 319–341. https://doi.org/10.1016/j.destud.2011.06.006
Jonas Žukas was born in 1979. He obtained a BA (2001) and MA (2004) in Sculpture from the Vilnius Academy of Arts. In 2021, he received a degree of PhD in History and Theory of Arts from the Vilnius Tech (former Vilnius Gediminas Technical University). Jonas is working in the field of spatial design and participates in fine art exhibitions as an installation and object author. In 2011, Jonas Žukas became a Lecturer of Product Design at Raffles Education Corporation (Singapore). Since 2015, he has been a Lecturer of the Department of Design of the Vilnius Tech Faculty of Architecture. His research interests are intuitiveness of the material environment shape.

Kostas Gaitanži was born in 1977 in Vilnius. He studied painting at the Vilnius Academy of Arts. Kostas acquired a Bachelor’s degree in 2001 and a Master’s degree in 2006. In 2019, he obtained the degree of Doctor of Arts (DA). He is a practicing artist and lecturer at the European Humanities University. His research interests are art, philosophy of mind and embodiment.

Darius Zabulionis was born in 1973 in Vilnius. In 1996, he obtained a Bachelor’s and in 1998 a Master’s degree in Civil Engineering from the Vilnius Tech (former Vilnius Gediminas Technical University). In 2003, Darius received a PhD degree in Technological Sciences. Since 2012, he has been a senior researcher of the Institute of Mechanics of the Vilnius Tech. His research interests are modeling of materials, mechanics of layered structures, cracking of outer layers of layered walls.

Contact Data

Jonas Žukas
E-mail: jonas.zukas@vilniustech.lt

Kostas Gaitanži
E-mail: gaitanzi@gmail.com

Darius Zabulionis
E-mail: darius.zabulionis@vilniustech.lt