**Invention Engineering – A Novel Approach to Support Creativity in Engineering, Practice and Research**

**J. NOENNIG*, S. WIESENHUETTER**

Faculty of Architecture, TU Dresden, Dresden, GERMANY

*e-mail: joerg.noennig@tu-dresden.de

**ABSTRACT** In engineering education, practice, and research, a central issue is how traditional thought patterns can be broken up by creative tools and impulses. This paper presents the outline for a method that supports the discovery of new sources of inspiration in search fields such as literature, film, fine art or music, and enables engineers to generate design alternatives in high speed and quantity. For this end, techniques from the design sciences, creativity and innovation research as well as digital information and knowledge technologies are reviewed and integrated into the conceptual approach of Invention Engineering. The aim is to develop and validate a process which provides artistic inspirations to engineers and is supported by algorithmic creativity and association tools. Thus four separate research challenges need to be addressed: a) Analysis of creative processes in engineering disciplines (inspiration, association, ideation, innovation) and their comparison to "Creative Patterns" of other domains; In addition, visions of the past and the socio-technical framework conditions of their implementation need to be explored in order to establish a model for the validation of the overall Invention Engineering method; b) Development of an "Inspiration Mining" method for obtaining creative impulses from non-engineering areas (e.g. literature, music, visual arts, film et al.); Respective search results need to be referenced with a semantic model and processed in a knowledge system (Idea Bank), which – as a kind of associative search engine – provides input for idea generation; c)Translation of established creativity and innovation research into an “Idea Engine” for generation of a large number of productive ideas; This can be done through combinatorial algorithms and methods of remote association, textual and visual-spatial idea matrices, that provide a fertile basis for radically new design and engineering ideas; d) Integration of the separate methods into a coherent process and validation of the creative support effect of the generated innovations by means of engineering psychology. This can be done on the basis of selected visionary ideas from the past (e.g. science fiction) that can be simulated on the basis of their associative foundations and implementation probabilities.

**Keywords** Invention Engineering; Creative Technique; Innovation Management

**ВИНАХІДНИЦЬКА ІНЖЕНЕРІЯ – НОВІЙ ПІДХІД ДО ПІДТРИМКИ ТВОРЧОСТІ В ІНЖЕНЕРІЇ, ПРАКТИЦІ ТА ДОСЛІДЖЕННІ

Дм. Р. НОННІГ, С. ВІСЕНЬХЮТЕР

Факультет архітектури, ТУ Дрезден, Дрезден, НІМЕЧЧИНА

**АНОТАЦІЯ** В галузі інжинерної освіти, практики та досліджень центральним питанням є те, як традиційні моделі мислення можуть бути розбиті творчими інструментами та імпульсами. В статті представлено схему методу, який підтримує відкриття нових перспектив натхнення у таких сферах, як література, кіно, образотворче мистецтво чи музика, і дозволяє інженерам створювати альтернативні дизайн-ідеї та у відкритий кількості. З цією метою методи з дизайнерських наук, творчості та інновацій, а також цифрової інформації та технологій тісно переплітаються та інтегруються в концептуальний підхід винахідницької інженерії. Метою є розробка та підтвердження процесу, який забезпечує художнє натхнення інженерам та підтримується алгоритмічними інструментами творчості та асоціації. Таким чином, потрібно вирішити чотири окремі проблеми дослідження: a) аналіз творчих процесів в інженерних дисциплінах (натуралізація, асоціація, ідеї, інновації) та їх порівняння з «креативними моделями» інших областей; крім того, необхідно вивчити бачення музикою та соціально-технічні рамки умови їх впровадження, щоб встановити модель для виходу заздалегідь залученої методи винахідницької інженерії; b) розробка методу «Натхнення для натхнення» для отримання творчих імпульсів з інженерних галузей (наприклад, література, музика, образотворче мистецтво, кіно та ін.); відповідні результати пошуку повинні посилатись на семантичну модель і оброблятися у системі знань (Ідеї Банк), навіть, як своєрідна асоціативна пошукова система, дає внесок для генерації ідеї; c) переклад значущих досліджень творчості та інновацій у «двигун ідеї» для генерації великої кількості продуктивних ідей; d) інтеграція окремих методів у цілісний процес і перевірка ефективності творчих підтримки творчих інновацій засобами інженерної психології; це можна зробити на основі відобраних умовних ідей із минулого (наприклад, наукової фантастики), які можуть бути змодельовані на основі їх асоціаційних основ та імпровізаційній реалізації.

**Ключові слова:** винахідницька інженерія; креативні методи; інноваційний менеджмент

---

**Introduction**

The history and practice of engineering disciplines such as architectural or civil engineering show that the potential of new possibilities from the introduction of new techniques or materials remained unused for a long time, because it was based on old thinking and design patterns that did not meet the potential of the new technical achievements. New design rules and applications are usually discovered slowly and often by chance. In
Research on creativity, established in the cognitive and behavioural sciences sees as critical creativity factors in individuals and groups the “out of box” breaking-up of existing thought patterns [5] and the semantic linkage of distant objects (Remote Association) [8]. In addition, many of the established learning and creativity techniques such as Synectics [4,9] are based on principles of exploration and the ability to use disturbances productively [10].

Innovation research, which, in contrast to creativity research, primarily investigates the effects of inventions and discoveries in socio-technical systems, emphasizes the principles of openness and disruption as central factors. Classical innovation research emphasized the moment of creative disturbance, even destruction [11]. More statistically oriented and dependency-oriented scenario methods for technology forecast (Kondratjew cycles, Delphi method) [12] also see external impulses and disturbances as decisive trigger for surprising new technical solutions. Such, the open innovation approach describes how valuable impulses in innovation ecosystems are based on the absorption of external inventions [13], through targeted involvement of end and extreme users [14] as well as through hacking processes [7]. They also show the risks arising from path dependencies and non-observance of external inventions (“not invented here” syndrome) [15].

Especially in ICT and software development, these findings have led to innovation processes such as Agile Development or Scrum, which ensure high creative output as well as successful implementation in markets and organizations. They enable the rapid uptake of external impulses and an "agile" realignment of the development processes. This responsiveness and openness is a fundamental condition of the innovation power of the current ICT and software industry. In the civil and architectural engineering and the related construction industry, however, comparable procedures are lacking.

Although the added value of disturbances, openness and agility has long been recognized in the field of creativity and innovation research, they are not very present and hardly used in the engineering sciences. The few existing approaches to scientifically comprehend the creative process for the creation of complex technical artifacts are based on the systematic solution of complex engineering problems by rule-based problem solving strategies e.g. the decomposition of complex problems into less complex problems [1,2]. Well-established design science methods such as Genrich Altshuller's TRIZ [16], Christopher Alexander's Pattern Language [17] or Richard Buckminster Fuller's Synergetics have at best led to practical computer aided invention tools, but not to surprisingly new solutions.

More aggressive innovation is created at the interface between Open Innovation and Design Science: the Design Thinking process pursues external and transdisciplinary impulses to generate disruptive product and solution visions. Going beyond this result-oriented approach again, more recent concepts of Art Thinking try
to use results-oriented, exploratory processes instead of
the forced product and visions of Design Thinking [18].

On technical level, such approaches are broadly
employed in the research and innovation departments of
large technology companies (Fig. 1) where they are
increasingly being supported by “intelligent” interaction
and analysis technologies. Here established creativity and
innovation methods are enhanced with AI and database
procedures, thus forming a Digital Innovation
Engineering approach.

Fig. 1 – Fujitsu Digital Future Center: Pattern Library of
creative solutions to support systematic generation of
innovations

While broadly established methods such as Pattern
Language or Design Thinking do not stand up to scientific
validation, the more robust Design Science methods
(Simon, Altshuller) only lead to incremental, path-
dependent innovations or optimizations. Discipline-bound
within their respective technical and conceptual
possibilities, they do not lead to radical innovation leaps,
as it may be expected from the discovery of ground-
breaking new engineering materials or processes. The
thinking of “hard” engineering can hardly integrate the
success factors of radical innovation (openness, disruption, agility), while on the other hand a translation
of the methods of innovation and creativity research into
engineering-scientific conception processes and their
support by advanced digital tools is rarely attempted.

Results

It is necessary to provide non-specialist sources of
inspiration, e.g. from the visual arts, literature, music,
film, science fiction, etc., as a source of inspiration in
order to achieve radically different design and
construction ideas. In the future, engineers need to have
valid algorithmic procedures upon which - after careful
description of their particular challenges - they can
receive inspiring impulses and associations, leading them
towards radically new approaches in design work,
experimentation, modelling, etc. In order to effectively
explore new ideas paths and to generate and evaluate new
visions in high speed and quantity, structured concept-
finding processes are necessary. Therefore we aim to fuse
useful approaches and principles from the fields of design
sciences, design and art thinking as well as creativity and
innovation research into a method of Invention
Engineering. Advanced methods of machine learning and
creativity-oriented data analysis open up excellent
opportunities to use previously unknown sources of
knowledge for engineers, and for inspiring radical new
conceptual paths [19].

As basic elements of the intended method we see a
digital AI assistant based on bot functionality which
proposes decision paths. Also, we have conceived a tool
for creating associative as well as logically linked idea
matrices in which users can freely navigate and ideas
"grow" quickly.

Our schematic future research outline combines
approaches and techniques, as outlined above, from the
design sciences, creativity and innovation research as well
as digital information and knowledge technologies. The
concrete goal of developing and validating a process
supported by algorithmic creativity and association tools
for the provision of artistic inspirations in order to
discover radically new engineering and constructions
approaches may be broken down in following four
separate research challenges, each of which targets at a
single method.

This research challenge aims at the analysis of
creative processes (inspiration, association, ideation,
innovation) commonly used in engineering disciplines,
and the comparison to "patterns of thought" of other
domains and open creativity techniques. In addition,
visions of the past and the socio-technical framework
conditions of their implementation need to be explored in
order to establish a model for the validation of the overall
Invention Engineering method.

![Fig. 2 – Creative Patterns: Investigating the structures of
creative thought and inventions](image-url)
This challenge comprises the development of techniques and technologies for use in areas outside engineering such as literature, music, visual arts, film et al. To be able to discover ideas and concepts that can provide creative impulses for engineering research, IT technologies such as text mining, web crawling or machine learning are available [21,22]. Respective search results need to be referenced with a semantic model and processed in a knowledge system (Idea Bank), which – as a kind of associative search engine – provides input for idea generation.

Fig. 4 – Idea Engine: Creative ideation based on Inspirational Matrices

The fourth research challenge addresses the integration of above mentioned processes and tools into a coherent methodology and process. Their validation is possible on the basis of selected visionary ideas from the past (e.g. science fiction) that can be simulated on the basis of their associative foundations and implementation probabilities. The creative supportive effect of the method and the realization potential of the generated innovations need to be assessed with means from fields like engineering psychology.

Conclusion

The initial research program sketched above will be pursued over the next months and years by the WISSENSARCHITEKTUR Laboratory of Knowledge Architecture at TU Dresden within larger research consortia and projects. We target at implementing and testing a complete Invention Engineering Process at TU Dresden within the next two years, and explore the research and innovation potential of the approach also beyond the scope of engineering education, research and practice.

Список літератури

1. Simon, H. The Sciences of the Artificial / H. Simon. MIT Press, 1969. – 248 p.
2. Hacker, W. Zeitweilige Gruppenarbeit für Prozessinnovationen: Grundlagen, Organisation und Wirkungen / W. Hacker // I. Jöns (Ed.), Erfolgreichere Gruppenarbeit. Konzepte, Instrumente, Erfahrungen, Wiesbaden: Springer Gabler. – 2016. – P. 25-35.
3. Gurtner, S. Programming Creativity: Methods for Empowering Innovation in Interdisciplinary Teams / S.
4. Koestler, A. The divine spark: The creative act in art and science / A. Koestler. — Berlin: Scherz. — 1966. — 143 p.
5. Gordon, W. Synectics: The development of creative capacity / W. Gordon. — Harper, New York 1961. — 180 p.
6. Stelze, B., Noennig, J. R., Jannack, A. Co-Design and Co-Decision: Decision Making on Collaborative Design Platforms / B. Stelze, J. R. Noennig, A. Jannack // Procedia Computer Science 112 Proc. of 21st Int. Conf. in Knowledge Based and Intelligent Information and Engineering Systems (KES2017). — Marseille. — 2017. — P. 2435-2444.
7. Gregory, R. W. Heuristic theorizing: Proactively generating design theories / R. W. Gregory, J. Muntermann // Information Systems Research. — 2014. — 25(3). — P. 639-653. — doi: 10.1287/isre.2014.0533.
8. Lee, C. S. A measure of creativity or intelligence? Examining internal and external structure validity evidence of the remote associates test / C. S. Lee, A. C. Huggins, D. J. Therriault // Psychology of Aesthetics, Creativity, and the Arts. — 2014. — 8 (4). — P. 446-460. — doi: 10.1037/a0036773.
9. Koziolek, S. Design by analogy: Synectics and knowledge acquisition network / S. Koziolek // Lecture Notes in Mechanical Engineering. — 2017. — P.257-273. — doi:10.1007/978-3-319-50938-9_27.
10. Koch, L. Imaginationen der Störung. Ein Konzept in: Behemoth / L. Koch, T. Nanz, J. Pause // A Journal on Civilisation, Imaginationen der Störung. — 2016. — Vol. 9, №. 1. — doi: 10.6094/behemoth.2016.9.1.885.
11. Schumpeter, J. Theorie der wirtschaftlichen Entwicklung / S. Schumpeter. — Berlin, 1912. — 216 p.
12. Kondratjew, N. Die langen Wellen der Konjunktur / Kondratjew, N. // Archiv für Sozialwissenschaft und Sozialpolitik. — 1926. — Band 56. — P. 573-609.
13. Chesbrough, H. Open Innovation. The New Imperative for Creating and Profiting from Technology / H. Chesbrough. — Harvard Business School Press, Boston, 2003. — 230 p.
14. Hipple, E. Lead Users. A Source of novel product concepts / E. Hipple // Management Science. — 1986. — Vol. 32. — P. 791–805.
15. Katz, K. Investigating the Not Invented Here (NIH) Syndrome: a look at the performance, tenure and communication patterns of 50 R&D project groups / K. Katz, T. Allen // R&D Management. — 1982. — Vol. 12, 1. — P. 7-19.
16. Chou, J. R. An ideation method for generating new product ideas using TRIZ, concept mapping, and fuzzy linguistic evaluation techniques / J. R. Chou // Advanced Engineering Informatics. — 2014. — 28(4). — P. 441-454. — doi: 10.1016/j.aei.2014.06.006.
17. Najari, A. From Alshtuller to Alexander: Towards a Bridge between Architects and Engineers / A. Najari, S. Dubois, M. Barth, M. Sonntag // Procedia CIRP. — 2016. — 39. — P. 119-124. — doi: 10.1016/j.procir.2016.01.176.
18. Schiuma, G. Arts catalyst of creative organisations for the fourth industrial revolution, Schiuma, Giovanni / G. Schiuma // Journal of Open Innovation: Technology, Market, and Complexity. — 2017. — P. 2199-8531.
19. Dahlstedt, P. Big Data and Creativity / P. Dahlstedt // European Review. — 2019. — 27 (3). — P. 411-439. — doi: 10.1017/S1062798719000073.
20. Oltețeanu, A.-M. Computationally resurrecting the functional Remote Associates Test using cognitive word associates and principles from a computational solver / A.-M. Oltețeanu, M. Schöttner, S. Schuberth // Knowledge-Based Systems. — 2019. — 168. — P. 1-9. — doi: 10.1016/j.knosys.2018.12.023.
21. Song, H. Design-by-analogy: Exploring for analogical inspiration with behavior, material, and component-based structural representation of patent databases / H. Song, K. Fu. // Journal of Computing and Information Science in Engineering. — 2019. — 19 (2). — № 021014. — doi: 10.1115/1.4043364.
22. Chen, L. An artificial intelligence based data-driven approach for design ideation / L. Chen, P. Wang, H. Dong, F. Shi, J. Han, Y. Guo, P.R.N. Childs, J. Xiao, C. Wu // Journal of Visual Communication and Image Representation. — 2019. — 61. — P. 10-22. — doi: 10.1016/j.jvcir.2019.02.009.

References (transliterated)

1. Simon, H. The Sciences of the Artificial. MIT Press, 1969, 248.
2. Hacker, W. Zeitweilige Gruppenarbeit für Prozesstionnovationen: Grundlagen, Organisation und Wirkungen. J. Jüns (Ed.), Erfolgreiche Gruppenarbeit. Konzepte, Instrumente, Erfahrungen, 2016, 25-35.
3. Gurtner, S., Jannack A., Noennig, J. Programming Creativity: Methods for Empowering Innovation in Interdisciplinary Teams. Proc. of Int. Forum for Knowledge Asset Dynamics, 2013, Zagreb, Croatia, 1858-1869.
4. Koestler, A. The divine spark: The creative act in art and science. Bern: Scherz, 1966, 143.
5. Gordon, W. Synectics: The development of creative capacity. Harper, New York, 1961, 180.
6. Stelze, B., Noennig, J. R., Jannack, A. Co-Design and Co-Decision: Decision Making on Collaborative Design Platforms. Proc. of 21st Int. Conf. in Knowledge Based and Intelligent Information and Engineering Systems (KES2017). Marseille, 2017, 2435–2444.
7. Gregory, R.W., Muntermann, J. Heuristic theorizing: Proactively generating design theories. Information Systems Research, 2014, 25 (3), 639-653, doi: 10.1287/isre.2014.0533.
8. Lee, C. S., Huggins, A. C., Therriault, D. J. A measure of creativity or intelligence? Examining internal and external structure validity evidence of the remote associates test. Psychology of Aesthetics, Creativity, and the Arts, 2014, 8 (4), 446-460, doi: 10.1037/a0036773.
9. Koziolek, S. Design by analogy: Synectics and knowledge acquisition network. Lecture Notes in Mechanical Engineering, 2017, 259-273, doi:10.1007/978-3-319-50938-9_27.
10. Koch, L., Nanz, T., Pause, J. Imaginationen der Störung. Ein Konzept in: Behemoth / L. Koch, T. Nanz, J. Pause // A Journal on Civilisation, Imaginationen der Störung. — 2016. — Vol. 9, №. 1. — doi: 10.6094/behemoth.2016.9.1.885.
11. Schumpeter, J. Theorie der wirtschaftlichen Entwicklung / S. Schumpeter. — Berlin, 1912. — 216 p.
12. Kondratjew, N. Die langen Wellen der Konjunktur / Kondratjew, N. // Archiv für Sozialwissenschaft und Sozialpolitik. — 1926. — Band 56. — P. 573-609.
13. Chesbrough, H. Open Innovation. The New Imperative for Creating and Profiting from Technology / H. Chesbrough. — Harvard Business School Press, Boston, 2003. — 230 p.
14. Hipple, E. Lead Users. A Source of novel product concepts / E. Hipple // Management Science. — 1986. — Vol. 32. — P. 791–805.
15. Katz, K., Allen, T. Investigating the Not Invented Here (NIH) Syndrome: a look at the performance, tenure and communication patterns of 50 R&D project groups. R&D Management, 1982, 12, 1, 7-19.

16. Chou, J. R. An ideation method for generating new product ideas using TRIZ, concept mapping, and fuzzy linguistic evaluation techniques. Advanced Engineering Informatics, 2014, 28(4), 441-454, doi: 10.1016/j.aei.2014.06.006.

17. Najari, A., Dubois, S., Barth, M., Sonntag, M. From Altshuller to Alexander: Towards a Bridge between Architects and Engineers. Procedia CIRP, 2016, 39, 119-124, doi: 10.1016/j.procir.2016.01.176.

18. Schiuma, G. Arts catalyst of creative organizations for the fourth industrial revolution, Schiuma, Giovanni. Journal of Open Innovation: Technology, Market, and Complexity, 2017, 2199-8531.

19. Dahlsrud, P. Big Data and Creativity. European Review, 2019, 27 (3), 411-439, doi: 10.1017/S1062797819000073.

20. Oltéanu, A.-M., Schöttner, M., Schubерт, S. Computationally resurrecting the functional Remote Associates Test using cognitive word associates and principles from a computational solver. Knowledge-Based Systems, 2019, 168, 1-9, doi: 10.1016/j.knosys.2018.12.023.

21. Song, H., Fu, K. Design-by-analogy: Exploring for analogical inspiration with behavior, material, and component-based structural representation of patent databases. Journal of Computing and Information Science in Engineering, 2019, 19 (2), 021014, doi: 10.1115/1.4043364.

22. Chen, L., Wang, P., Dong, H., Shi, F., Han, J., Guo, Y., Childs, P.R.N., Xiao, J., Wu, C. An artificial intelligence based data-driven approach for design ideation. Journal of Visual Communication and Image Representation, 2019, 61, 10-22, doi: 10.1016/j.jvcir.2019.02.009.

About authors

Joerg Rainer Noennig – Prof. Dr.-Eng., Director of Wissensarchitektur - Laboratory of Knowledge Architecture, Faculty of Architecture, TU Dresden, Dresden, Germany; e-mail: joerg.noennig@tu-dresden.de.

Дж. Ноенніг – професор, доктор наук, директор Висенсархітектур – Лабораторія архітектурних знань, факультет архітектури, ТУ Дрезден, Дрезден, Гермàнія; e-mail: joerg.noennig@tu-dresden.de.

Sebastian Wiesenhuetter – Research Associate, Wissensarchitektur – Laboratory of Knowledge Architecture, Faculty of Architecture, TU Dresden, Dresden, Germany; e-mail: sebastian.wiesenhuetter@tu-dresden.de.

Себастіан Вісенхьютер – науковий співробітник, Висенсархітектур - Лабораторія архітектурних знань, факультет архітектури, ТУ Дрезден, Дрезден, Гермàнія; e-mail: sebastian.wiesenhuetter@tu-dresden.de.

Please cite this article as:

Noennig, J., Wiesenhuetter, S. Invention engineering – a novel approach to support creativity in engineering, practice and research. Bulletin of NTU “KhPI”. Series: New solutions in modern technologies. – Kharkiv: NTU “KhPI”, 2019, 1, 42-47, doi:10.20998/2413-4295.2019.01.05.

Будь ласка, посилайтесь на цю статтю наступним чином:

Noennig, Дж. Винахідницька інженерія – новий підхід до підтримки творчості в інженерній, практиці та дослідження / Дж. Ноенніг, С. Вісенхьютер // Вістник НТУ «ХПІ». Серія: Нові рішення в сучасних технологіях. – Харків: НТУ «ХПІ», 2019. – № 1. – С. 42-47. – doi:10.20998/2413-4295.2019.01.05.

Пожалуйста, ссылайтесь на эту статью следующим образом:

Ноенніг, Дж. Изобретательная инженерия – новый подход к поддержке творчества в инженерии, практике и исследовании / Дж. Ноенніг, С. Вісенхьютер // Вестник НТУ «ХПІ», Серія: Нові рішення в сучасних технологіях. – Харків: НТУ «ХПІ», 2019. – № 1. – С. 42-47. – doi:10.20998/2413-4295.2019.01.05.

ANPASSADURACИЯ В области инженерного образования, практики и исследований центральным вопросом является то, как традиционные модели мышления могут быть развиты творческими инструментами и ими пользоваться. В статье предсказана схема метода, который поддерживает открытие новых источников вдохновения в таких сферах поиска, как литература, кино, изобразительное искусство или музыка, и позволяет инженерам создать альтернативные дизайны быстро и в большом количестве. С этой целью разработана методика из дизайнерских наук, творчества и инноваций, а также цифровой информации и технологий познаний пересматриваются и интегрируются в концептуальный подход изобретательной инженерии. Целью является разработка и подтверждение процесса, который обеспечивает художественное вдохновение инженеров и поддерживает алгоритмические инструменты творчества и ассоциаций. Таким образом, можно решить четыре отдельных проблем: а) анализ творческих процессов в инженерных дисциплинах (вдохновение, ассоциации, идеи, инновации) и их сравнение с "кreatивными моделями" других областей; кроме того, необходимо изучить введение прошлого и социально-технические рамочные условия внедрения, чтобы установить модель для валидации общего метода изобретательной инженерии; б) разработка метода ".avatar" для получения творческих импульсов из инженерных областей (например, литературы, музыки, изобразительного искусства, кино и др.) соответствующие результаты поиска должны собираться на семантической модели и обрабатываться в системе знаний (Банк идей), которая, как своеобразная ассоциативная поисковая система, дает исход для генерирования идей; в) перевод установленных исследований творчества и инноваций в "двигатель идеи" для генерации большого количества продуктивных идей; это можно сделать с помощью комбинаторных алгоритмов и методов удаленной ассоциации, текстовых и визуально-пространственных матриц идей, которые дают плодотворную основу для радикальных новых инженерных и инженерных идей; г) интеграция отдельных методов в целостный процесс и проверка эффекта творческой поддержки созданных инноваций средствами инженерной психологии; это можно сделать на основе обработанных оображаемых идеи из прошлого (например, научной фантастики), которые могут быть смоделированы на основе их ассоциативных оснований и вероятностей реализации.

Ключевые слова: изобретательная инженерия, креативные методы; инновационный менеджмент

Поступила (received) 08.08.2019