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Technology Status Visualisation Using Patent Analytics: Multi-Compartment Refrigerators Case

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***Abstract*— Developers of new products and services need to do thorough analysis of information available in patent databases, since this is of most important in order to have a contemporary status on defined topics of interest and determination of the possibility to protect rights. Beside developers, companies also analyse patent data and use collected information for defining future research and development plans and market strategies. The core of presented patent analytics uses various text processing methodologies required in the process of the patent portfolio visualization. As food storage devices, like refrigerators, are under the most arguable topics in the last decade, this paper shows qualitative and quantitative analysis of the patent portfolio created for this topic using available patent search engines. Conducted patent analytics can be used by interested parties involved in different phases of food product life cycle.**

***Keywords*— technology analysis, patent analysis, patent portfolio visualization, text mining, food storage**

I. INTRODUCTION

Limited natural resources (land, water, energy) and cost-effective solutions, capable to produce sufficient, safe and nutritious food for all, are priorities of the modern world [1]. Harvested food products, during their life cycle from the producer to the consumer are stored in refrigerators. A refrigerator is a appliance that consists of a thermally insulated compartment and a heat pump (mechanical, electronic or chemical) that transfers heat from the inside of the fridge to its external environment so that the inside of the fridge is cooled to a temperature below the ambient temperature of the room. Refrigeration is an essential food storage technique in developed countries. The lower temperature lowers the reproduction rate of bacteria, so the refrigerator reduces the rate of spoilage. A refrigerator maintains a temperature a few degrees above the freezing point of water. Optimum temperature range for perishable food storage is 3 to 5 °C. There are many innovations related to construction and control of refrigerators.

Refrigerators that are in usage in households use one compressor with two evaporators connected in series to reduce capital cost. Limited by the refrigerator structure, there is a large temperature difference between the refrigerator cell (5°C) and refrigerator evaporator (−25°C). This large temperature difference creates great irreversibility of the cycle and decreases system efficiency. In order to avoid such defects, many new systems have been proposed to improve the performance of domestic refrigerators. In 1975, Lorenz and Meutzner used the zeotropic mixture R22/R11 in a system of evaporators connected in series, and a 20% efficiency improvement was obtained [2]. Experimental results showed that the coefficient of performance (COP) of the new cycle in refrigerators controlled by a solenoid valve is 8.41% higher than the Lorenz–Meutzner cycle [3]. In [4] new control strategy for this system to solve the temperature control problem is proposed. There are also other designers that have used phase change materials in domestic refrigerators to reduce the on/off frequency of the compressor; their experimental results showed that the COP can be increased by 8% [5-7]. Compression-injection hybrid system has influenced development potential as the COP improvement of domestic refrigerators is more than 7% [8].

Improper food storage is one of the basic factors of major routes of food handling failures [9]. Another important problem is food storage in places which are often too warm [10]. In order to improve food storage in refrigerators there are different patents that can be used, but first, patent analytics should be done in order to be aware of the technology status.

Patent analytics can help companies involved in different phases of food product life cycle (production, distribution, processing, sale of food products, etc.) to improve their practice. By carrying out the analysis of patent historical data, its citations, relations in complex citation networks, and International Patent Classification (IPC) for identification of technologically similar assignees, the firms can develop their own R&D directions. There are research papers that use patents as a proxy of agriculture subfields. Qualitative and quantitative analysis of patent portfolio created on food safety storage technology is given in [11].

This paper analyses the current patents status in the field of multi-compartment refrigerators. The generated patent portfolio analysis consists of the trend analysis, dominant technology fields' identification, and visualization of patents in technology space, as well as application and examination of presentation quality for various algorithmic methods required in the portfolio analysis.

The paper is structured as following: Data acquisition and methodology that has been used for patent bibliographic data gathering are given in the next section. Analysis of the basic characteristics of created multi-compartment refrigerators patent portfolio is presented in the third section. Patents similarities and companies technological relations visualized in technology space are presented in section four. Discussion and conclusion make the last section, which explains the obtained results and gives appropriate conclusions.

II. Data Acquisition and Methodology

The aim of this paper is patent portfolio analysis and visualization of its basic characteristics. The created patent portfolio is consisted of patents focused in the domain of multi-compartment refrigerators. This patent portfolio was generated by browsing through publicly available patent search engines, including Espacenet (EPO) and Google patent search. Firstly, a set of keywords was defined and applied on the abstract section of patents. Each selected abstract had to have at least one term from the keywords set, which contained the required terms: food storage or cooling unit or refrigerator; and optional terms: temperature zones, humidity/temperature control, evaporator, chamber and compartment. Finally, we filtered out all inactive patents. As a result, we created a patent portfolio named MCR (Multi-Compartment Refrigerators) with 49 documents, consisting of either granted patents or pending patent applications.

Analysis of the MCR patent portfolio consists of evaluation of the following characteristics:

- Patent applications trend;
- Most frequent IPC groups and subgroups used;
- Visualization of patents technology space using text to vectors transformation and topics modelling.
- Visualization of the similar patents and representative companies in the technology space.

The first two evaluation steps of the MCR patent portfolio analysis use simple statistical procedures. However, the preparation of patents visualization in the technology space requires the usage of an automated text mining procedure. The complete claims section from each patent document was used for text mining purposes. The claims represent the most important section of the patent document. Their purpose is to define the subject matter and the scope of the invention. The independent claim contains all essential features necessary to satisfy the legal requirements of novelty and inventive steps of the protected invention.

This automated processing of the MCR patent dataset consists of the following main phases: text preparation, text pre-processing, text transformation into vector representation and vector dimension reduction. During text preparation, claims were extracted from a patent database. Text pre-processing from the claim list includes removing punctuation marks, removing all words and tags shorter than three characters, excluding all tags containing digits, converting all letters in words to lowercase letters and filtering "stop" words. Besides the usual "stop" words like conjunctions, pronouns, and suggestions, specific words that are characteristic for claim language, such as 'method', 'system', 'comprising', 'wherein', etc., are also filtered out. Each individual claim was transformed into a single vector using a neural network, resulting in a series of numerical vectors, where each vector represents a corresponding claim section. This transformation was conducted using a learning technique called Paragraph Vector (PV) [12], which can be utilized on text of arbitrary length. This way, models for predicting the next word were formed, depending on its preceding words that maximize log probability, while their combination generated a vector representation of the segments in the text. Resulting vectors have had large dimensions not suitable for graphic presentation. For this reason, the dimension of the PV vector was reduced to only two coordinates. Several dimensionality reduction approaches for reduction of the PV vectors was investigated, especially Multidimensional scaling (MDS) [13], Stochastic Neighbor Embedding (SNE) [14], Autoencoder [15] and Isomap [16]. The MDS inputs represent proximity data between PV items given by a dissimilarity matrix. MDS mapped PV items to a two-dimensional embedding space in a way that the given dissimilarities became well approximated inter-item distances. The two-dimensional coordinate space output of MDS mapping was used for visualization of patents. Other dimensionality reduction approaches are explained in the fourth section.

Identification of most likely used technologies in each document of the MCR patent portfolio is realised using the topic modeling approach. Topic models [17] are probabilistic generative models initially created to model texts and identify latent semantics underlying document collection. Topic models set words with similar semantics into the same group called topic and project documents into a topic space. Each topic is represented as a multinomial distribution over a given vocabulary and each document is a mixture of hidden topics.

III. The Multi-Compartment Refrigerators Portfolio Basic Characteristics Analysis

Multi-compartment refrigerators technology is not a new concept. For the observed period (2011-2017), an annual count of filed patent applications for the MCR portfolio is shown in Fig. 1. The chart shows that no clear trend in the number of patent applications in this field is present.

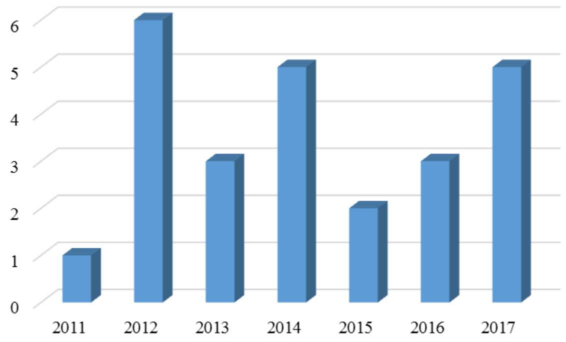


Fig. 1 The number of patent applications per year in the MCR portfolio

The countries with the higher number of submitted patent applications are shown in Fig. 2. The presented bar chart shows that the majority of patent applications are being submitted in China and Japan. This fact is expected because the majority of patent assignees from MCR portfolio are companies from these countries.

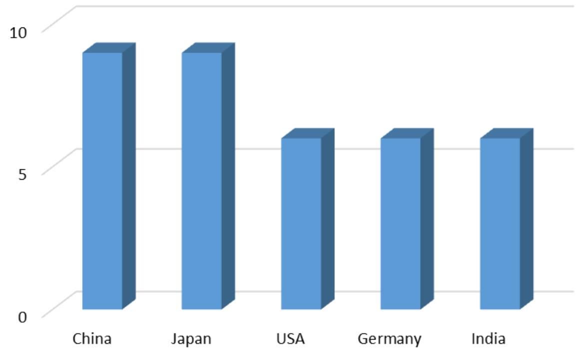


Fig. 2 Main countries of submitted patent applications in MCR portfolio

Patent documents in patent databases are sorted into technical fields covering all technological areas. Patents are sorted by different classification systems, from which the IPC system is most frequently used. Currently, IPC divides technology into approximately 70,000 sub-areas. Every patent, depending on the technical broadness of the covered invention, may have several IPC codes assigned to it. The MCR patent portfolio is characterized with six representative IPC groups. Table I shows these main six IPC groups, together with an explanation of each code and a count of its appearance in the portfolio's patents. From the code explanations given in the table, it can be observed that these categories dominantly characterize cooling gas arrangements, refrigeration units and constructional features.

TABLE I MAIN IPC GROUPS IN THE MCR PORTFOLIO

IPC group	**IPC group code explanation**	**# patents**
F25D11	Refrigerators, cold rooms or cooling or freezing apparatus	35
F25D17	Arrangements for circulating cooling gas e.g. air, within refrigerated space	32
F25D23	General constructional features	15
F25D19	Arrangements or mounting of refrigeration units with respect to devices	12
F25D29	Arrangements or mounting of control or safety devices	11
F25B5	Refrigerators, cold rooms or cooling or freezing apparatus with several evaporators circuits for varying refrigerating capacity	5

In the IPC classification system, technological group codes were further separated in dozens more detailed subgroups. A precise overview of technological fields is visible through IPC subgroups present in the MCR portfolio. Table II contains an explanation of five most frequent IPC subgroups in the portfolio. From Table II and Fig. 3, we can see that the observed patents are mostly focused on two aspects. The most dominant aspect covers refrigerators or cooling apparatus with cooling compartments at different temperatures. Another topic is the forced circulation of cooling fluids.

TABLE II THE MAIN IPC SUBGROUPS IN THE MCR PORTFOLIO

IPC code	**IPC subgroup code explanation**	**# patents**
F25D11/02	Refrigerators, cold rooms or cooling or freezing apparatus with cooling compartments at different temperatures	27
F25D17/06	For forced circulation of cooling fluids, e.g. air within refrigerated space	19
F25D19/00	Arrangements or mounting of refrigeration units with respect to devices or objects to be refrigerated	8
F25D17/08	For forced circulation of cooling fluids, e.g. air within refrigerated space by using ducts	8
F25D29/00	Arrangements or mounting of control safety devices for refrigerators	7

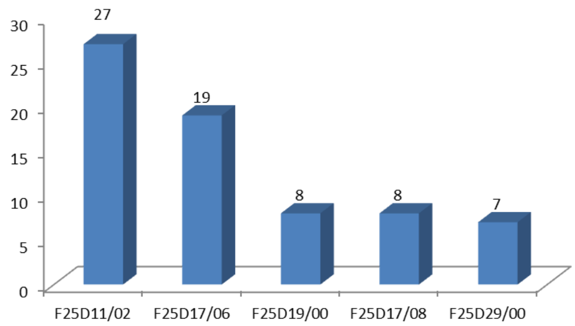


Fig. 3 The most frequent IPC subgroups of the MCR portfolio

IV. TECHNOLOGY SPACE VISUALIZATION OF THE MULTI-COMPARTMENT REFRIGERATORS PATENT PORTFOLIO

In order to detect similar patents and technological similarities between companies, we used automatic procedures of text mining as well as topics modelling, which are shortly described in the second section. Both procedures use text of the complete claims section as its input, from all patents in the MCR portfolio.

If distances between points in technology space are considered as measure of similarity between corresponding patents, the most appropriate distance metric should be selected. We explore sets of pairs for most similar patents from the MCR portfolio when different distance measures are applied on the matrix of claims section vectors generated by the described text mining procedure. Four distance measures are used: Euclidean, cosine, correlation and Mahalanobis distance. Different distance metrics for five pairs of patents with smalest distances are comparatively given in Table III, in ascending order. Due to easier readability of the table, three observed pairs with highest appearances in all distance lists are marked with different colors. Naturaly, smallest distance corresponds to the most similar patent pairs. The patent pairs with highest rating in all distance lists are marked with red, green and blue. Patents presented in Table III are marked with their application numbers. Having in mind positions in the given distance lists of the most similar pairs, the cosine distance is adopted as the patents similarity measure in the following analysis, although the correlation shown the same behaviour. Interestingly, further analysis of patents' original asignee has shown that each patent pair from Table III has the same original assignee, i.e. the applicant of both patents from the patent pair is the same company. A more detailed list of patents with the same applicant company which belong to the clossest three patent pairs, accordning to the cosine distance, are shown in Table IV. With further analysis of applicants of the patent pairs' sorted list continuation, we discovered first three patent pairs with diffrent applicant companies not till eighth, tenth, and twelvth positition. Details of these patents are given in Table V. From the table we can notice the following companies' pairs with most similar patents: Panasonic – Mitsubishi; Mitsubishi – Hisense; and Bosch Siemens – Zanussi. Moreover, as an indication of patent pairs similarity, the fact that they have completely identical IPC subgroup codes confirms these findings. A detailed insight into the text of patents from Table V additionaly confirms these allegations.

TABLE III LISTS OF THE MOST SIMILAR PATENT PAIRS ACCORDING TO DIFFERENT DISTANCE METRICS

#	Euclidean		Cosine		Correlation		Mahalanobis	
1	CN201710743292.1	CN201721074479.9	CN201710743292.1	CN201721074479.9	CN201710743292.1	CN201721074479.9	CN201710743292.1	CN201721074479.9
2	CN201410849467.3	CN201420866370.9	CN201410849467.3	CN201420866370.9	CN201410849467.3	CN201420866370.9	JP2008091137	JP2008239145
3	JP2008091138	JP2008239145	AU2014368139	SG11201602822X	AU2014368139	SG11201602822X	CN201410849467.3	CN201420866370.9
4	JP2008091137	JP2008239145	JP2008091138	JP2008239145	JP2008091138	JP2008239145	AU2014368139	SG11201602822X
5	AU2014368139	SG11201602822X	JP2008091137	JP2008239145	JP2008091137	JP2008239145	JP2008091137	JP2008091138

TABLE IV THE LIST OF THREE CLOSEST PATENT PAIRS IN THE MCR PORTFOLIO

#	Publication number	Application number	IPCs	Title	Applicant
1	CN107300288A	CN201710743292.1	F25D11/02 F25D17/06 F25D23/02	Cross side-by-side combination refrigerator with cycle temperature changing function	HEFEI MEILING
	CN207132617U	CN201721074479.9	F25D11/02 F25D17/06 F25D23/02	Cross of taking circulation alternating temperat. to refrigerator that opens door	HEFEI MEILING
2	CN104534776A	CN201410849467.3	F25D11/02 F25D17/06 F25D29/00 F25D19/00	Air-cooled refrigerator	HEFEI MIDEA REFRIGERATOR
	CN204478630U	CN201420866370.9	F25D11/02 F25D17/06 F25D29/00 F25D19/00	Air cooled refrigerator	HEFEI MIDEA REFRIGERATOR
3	AU2014368139B2	AU2014368139	F25D11/02	Refrigerator	MITSUBISHI ELECTRIC
	SG11201602822XA	SG11201602822X	F25D11/02	Refrigerator	MITSUBISHI ELECTRIC

TABLE V THE LIST OF THREE CLOSEST PATENT PAIRS WITH DIFFERENT APPLICANTS IN THE MCR PORTFOLIO

#	Publication number	Application number	IPCs	Title	Applicant
1	JP2009243777A	JP2008091137	F25D11/02 F25C1/24	Refrigerator	PANASONIC
	SG11201602822XA	SG11201602822X	F25D11/02	Refrigerator	MITSUBISHI ELECTRIC
2	JP6422513B2	JP2016574549	F25D17/08 F25D21/08	Refrigerator	MITSUBISHI ELECTRIC
	CN206531343U	CN201720187529.8	F25D11/02 F25D19/04 F25D17/06 F25D21/06	Three room refrigerators	HISENSE SHANDONG REFRIGERATOR
3	EP2126482B1	EP2007847278	F25B5/04 F25B41/06 F25D11/02 F25D17/06	Cooling furniture comprising two thermally separate compartments	BOSCH SIEMENS HAUSGERATE
	WO2002046668A1	PCT/EP2001/011522	F25B41/06 F25B49/02 F25D11/02 F25B5/04	Refrigeration appliance with a plurality of storage compartments	ZANUSSI ELETTROMECCANICA

In order to make MCR patent portfolio visual presentation in the technology space even more accurate, we have tried several approaches of data dimensionality reduction. Among the many available methods of dimensionality reduction, we have examined the following well-known algorithms: Multidimesional scaling (MDS), Stochastic Neighbor Embedding (SNE), Autoencoder and Isomap.

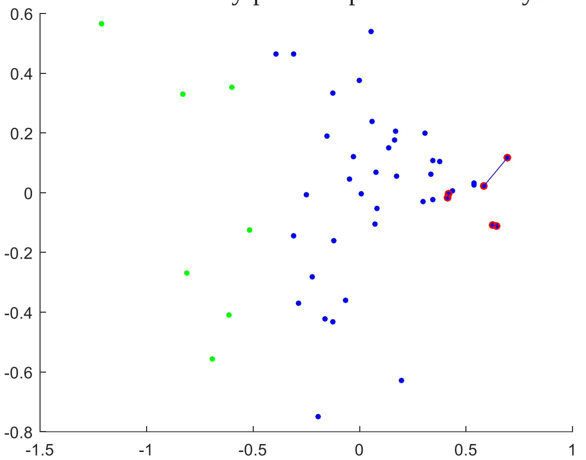
The MDS [13], as non-linear dimensionality reduction technique, uses given dissimilarities between pairs of items, and this technique is already described in short in the second section. The basic idea behind SNE [14] is to minimize the difference between specially defined conditional probability distributions that represent similarities, calculated for the data points in both the high and low dimensional representations. It models each high-dimensional vector by a two-dimensional point in such a way that similar vectors are modelled by nearby points and dissimilar ones are modelled by distant points with high probability.

The Autoencoders are unsupervised learning neural networks, and they are often used for the purpose of dimensionality reduction [15]. Their output layer has the same number of nodes as the input layer, and the cost function is some measure of the reconstruction error.

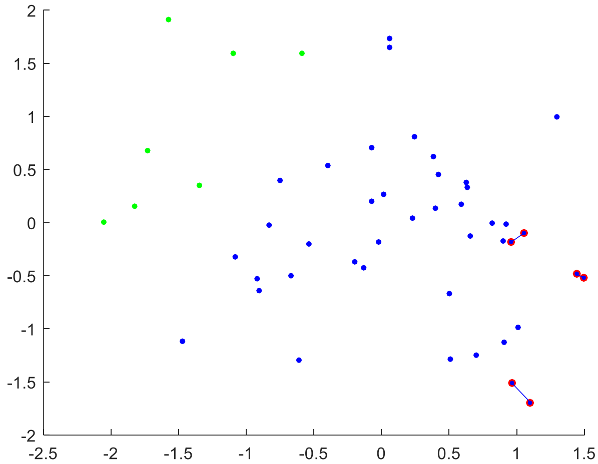
The Isometric Mapping (Isomap) [16] can be viewed as an extension of MDS. It seeks a lower-dimensional embedding which maintains geodesic distances between points. The Isomap defines the geodesic distance to be the sum of edge weights along the shortest path between two nodes of a weighted graph.

In order to verify usefulness and accuracy of the technology space of MCR patent portfolio generated by various dimensionality algorithms, two additional characteristics of this portfolio are applied: the patent similarity and identified topics in the MCR portfolio. The scrutinizing positions and distances of most similar patent pairs in the created technology spaces, we may assess how the selected method truly presents patents similarity. The cosine distance was used as measure of similarity. Moreover, clear separation of patents clustered in different topics may confirm correctness of the generated technology space. The topic modelling procedure performed on text extracted from patents' claims section is shortly described in the second section of the paper. Two identified topics in the MCR portfolio consist of 42 and 7 patents, respectively. The first topic named Cooling Compartments Control (CCC) contains patents related to refrigerators and cooling storage devices with compartments including temperature and evaporation control devices. The second topic named Thermal Energy Transfer and Insulation (TETI) considers structure, wall materials, thermal energy processes and assembling of cooling units.

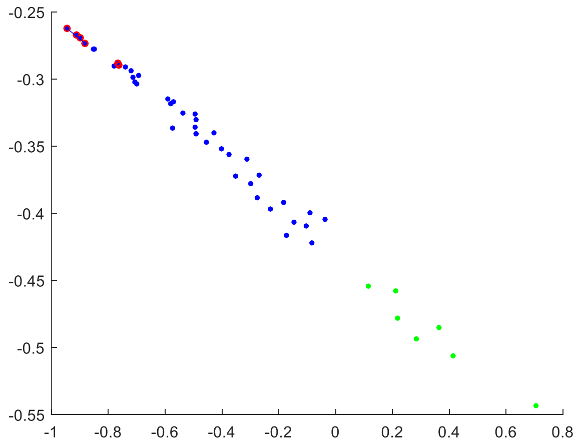
The results of applied four selected dimensionality reduction algorithms on MCR patent portfolio claims sections text data are shown in Fig. 4 (a)–(d). Patents assigned to the topic CCC are marked with blue points, and patents belonging to the TETI topic are marked as green points. In all diagrams both topics are clearly grouped and mutually separated. Moreover, the most similar patents pairs, given in Table IV, are all grouped in the edge region of the CCC topic, and on the opposite side of the boundary between two topics. The autoencoder method has shown least descriptive graphic output, while MDS and Isomap gave very similar results. For this reason, only MDS and SNE are used in the following graphical presentations.



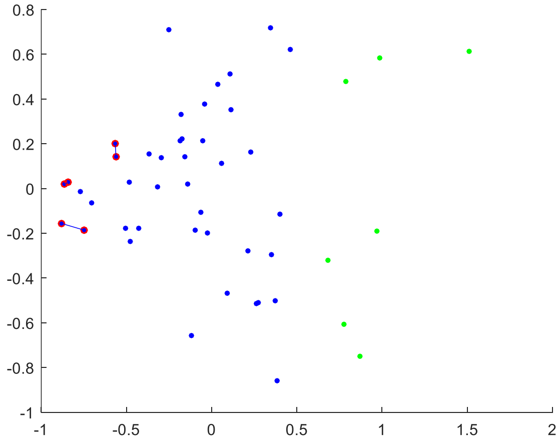
a) MDS algorithm



b) SNE algorithm



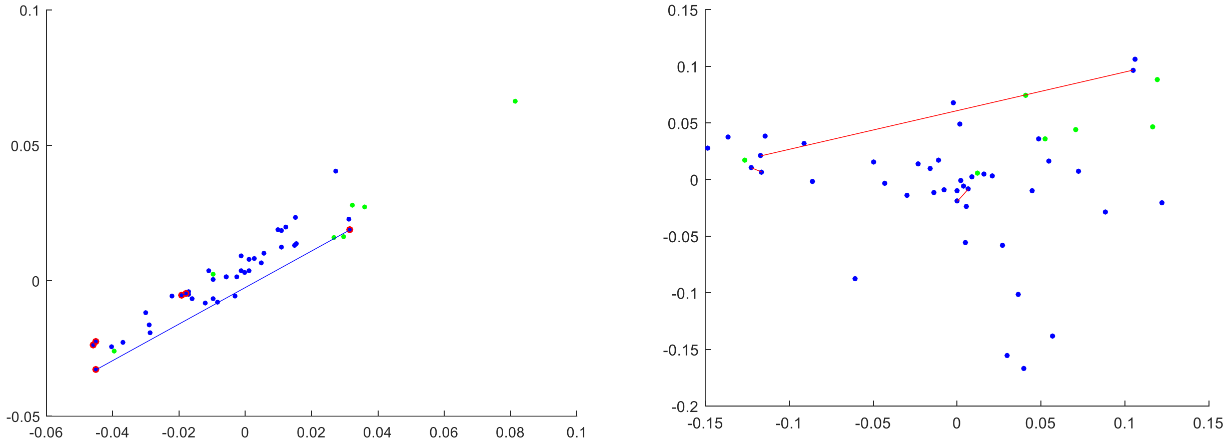
c) Autoencoder algorithm



d) Isomap algorithm

Fig. 4. Technology space of MCR patent portfolio based on the claims section text mining (blue-CCC topic, green-TETE topic)

Quality of generated technology spaces using vectors transformed from the text of claims sections of the MCR patent portfolio is compared with an alternative methodology. Namely, the technology space is possible to generate using standard patent classification codes (IPC or CPC) [18]. The CPC (Cooperative Patent Classification) lists which characterize technology classes of patents are processed using the Term Frequency-Inverse Document Frequency (TF-IDF) algorithm. The TF-IDF is a well-known statistical method for determining the importance of words within a document, which belongs to a large document set [19]. The output of the applied TF-IDF algorithm is a matrix whose rows represent relative frequency appearance of each CPC code in all patents of the MCR portfolio. In order to visualize relations between companies in the technology space based on CPC codes, reduction of the TF-IDF output matrix is conducted using MDS and SNE procedures. Fig. 5 shows scatter diagrams of the MCR patent portfolio technology space based on CPC codes transformed by the TF-IDF algorithm and processed by the selected dimensionality reduction techniques. It is easy to observe incorrect mixture of patents belonging to different topics. Also, the cosine distance of one patent pair is unrealistically large, which means that the visualization in Fig. 5 has lost accuracy in comparison to presentation given in Fig. 4. These remotely placed points correspond to the third patent pair from Table IV. The reason of this unwanted warping of technology space is because these two patents have only one CPC code. Identity of a single CPC code was not enough to preserve patent pair similarity during the process of dimensionality reduction.

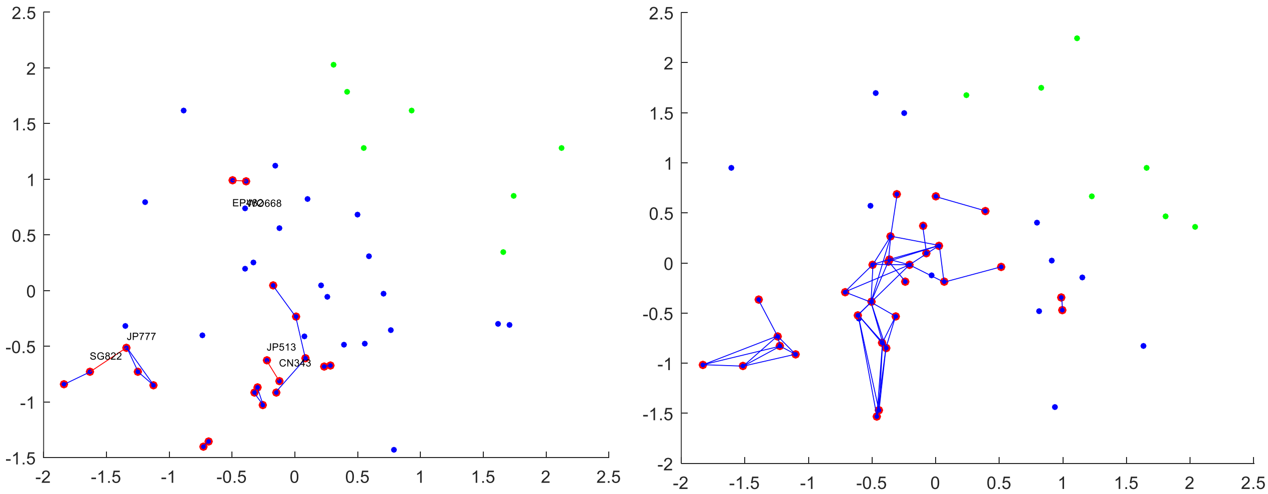


a) MDS algorithm

b) SNE algorithm

Fig. 5. Technology space of MCR patent portfolio using the TF-IDF processed CPC codes (blue-CCC topic, green-TETE topic)

With an increase in the number of displayed similar patent pairs, it is easy to observe an appearance of two clearly separated groups. Fig. 6 shows 15 and 50 patent pairs in technology space of MCR patent portfolio based on the text processing of the claims sections and using SNE dimensionality reduction. Both groups belong to the CCC topic. All patents that correspond to these lists of similar patents are circled in red color. Although, mutualy unconnected, both observed patent groups are close to each other in the technology space. All patents from both groups are related to the same technical field - refrigerators with two or three thermally separated compartments designed for different cooling/freezing temperatures. Additionally, in Fig. 6.a) three closest patent pairs filed from different applicants are marked, which are already discused above and presented in Table V (marked with abbreviated publication numbers and linked with red lines).



a) First15th the most similar patent pairs

b) First fifty the most similar patent pairs

Fig. 6. The most similar patent pairs in the technology space of MCR patent portfolio based on the claims section text; SNE dimensionality reduction; (blue-CCC topic, green-TETE topic)

Finally, we compared patents of four refrigerator manufacturers, present in the portfolio with their patents, and included in world's top ten refrigerator brands [20] (see Fig. 7). Panasonic's patents are most diverse due to their dispersion over the MCR portfolio technology space. Opposed to that, Hitachi's patents are very similar to each other.

V. Conclusions

Through analysing of multi-compartment refrigerators patent portfolio patents' data, we come to a conclusion that China and Japan are two main countries concerning patent applications in this field. We demonstrated that this portfolio, according to information extracted from IPC subgroups, dominantly covers refrigerators with cooling compartments at different temperatures. Several computer based automatic procedures are applied for generating technology space of the MCR patent portfolio: text mining of claims sections using words to vector transformation; topics modelling; and TF-IDF transform of patents' CPC codes. Additionally, we analysed various dimensionality reduction methods which are a necessary step in the process of portfolio graphical presentation. It is shown that the visualized technology space of the portfolio using MDS or SNE methods has similar descriptive capabilities. The cosine distance metrics has shown the most acceptable ability to realistically present similarity between patents in the technology space of the MCR portfolio. Moreover, it has been proven that the quality of generated technology spaces, using vectors transformed from the text of claims sections of the MCR patent portfolio, is much truthful than the TF-IDF based transform of CPC patents' codes. Finally, we have shown that the visualized technology space of the portfolio can be used for the assessment of technological similarities or discrepancies between companies.

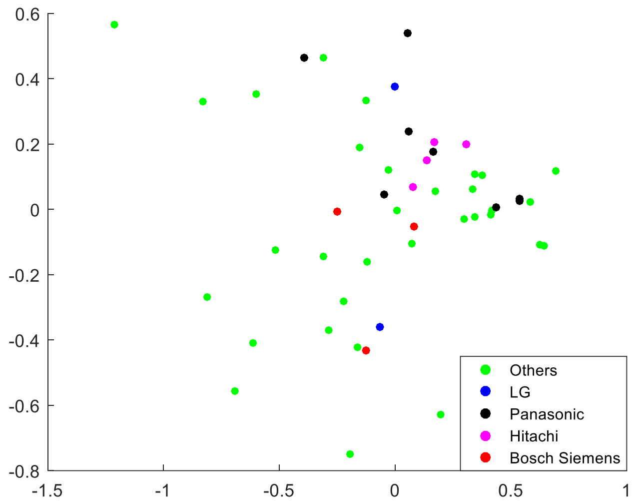


Fig. 7. Companies' patents distribution in the MCR portfolio: MDS dimensionality reduction

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References

[1] Food and Agriculture Organization of the United Nations, "Global food losses and food waste – extend, causes and prevention", 2011. Report available online at: http://www.fao.org/docrep/014/mb060e/mb060e.pdf

[2] K. Lorenz & Meutzner, "On application of non-azeotropic two component refrigerants in domestic refrigerators and home freezers", in: XIV Int. Congress of Refrigeration, Moscow, 1975.

[3] M. Lavanis, I. Haider & R. Radermacher, "Experimental investigation of an alternating evaporator duty refrigerator/freezer", ASHRAE Trans. 104,1103, 1998.

[4] Z. Lu & G. Ding, "Temperature and time-sharing running combination control strategy of two-circuit cycle refrigerator–freezer with parallel evaporators", Appl. Therm. Eng. 26, 1208–1217, 2006.

[5] A.C. Marques, G.F. Davies, G.G. Maidment, J.A. Evans & I.D. Wood, "Novel design and performance enhancement of domestic refrigerators with thermal storage", Appl. Therm. Eng., 63, 511-519, 2014.

[6] R. Elarem, S. Mellouli, E. Abhilash & A. Jemni, "Performance analysis of a household refrigerator integrating a PCM heat exchanger", Appl. Therm. Eng., 125, 1320–1333, 2017.

[7] S. Tegeltija, M. Lazarevic, S. Stankovski, V. Todorovic & G. Ostojic, "Heating circulation pump disassembly process improved with augmented reality", Thermal Science, 20, pp. S611-S622, 2016.

[8] X. Liu, J. Yu & G. Yan, "Theoretical investigation on an ejector–expansion refrigeration cycle using zeotropic mixture R290/R600a for applications in domestic refrigerator/freezers", Appl. Therm. Eng., 90, 703–710, 2015.

[9] J. Tache & B. Carpentier, "Hygiene in the home kitchen: Changes in behaviour and impact of key microbiological hazard control measures", Food Control, 35 (1), pp. 392-400, 2014.

[10] I.M. Marklinder, M. Lindblad, L.M. Eriksson, A.M. Finnson & R. Lindqvist, "Home storage temperatures and consumer handling of refrigerated foods in Sweden", Journal of Food Protection, 67 (11), pp. 2570-2577, 2004.

[11] D. Kukolj, G. Ostojic, S. Stankovski, S. Nemet, Food storage quality: Status of technology through patent analysis, Journal of Mechatronics, Automation and Identification Technology 3(4) pp. 6–11 http://jmait.org/volume-3-issue-4-2018/.

[12] Q. Le, & T. Mikolov, "Distributed Representations of Sentences and Documents", 31st Int. Conf. on Machine Learning, Beijing, China, June 21-26, 2014.

[13] A. Buja, D. Swayne, M. Littman, N. Dean, H. Hofmann & L. Chen, "Data Visualization with Multidimensional Scaling", Journal of Computational and Graphical Statistics, vol.17(2), pp.444-472, 2008.

[14] Hinton G. and Roweis S., Advances in Neural Information Processing Systems 15 (MIT Press, Cambridge, 2003), pp. 833–840.

[15] G. Hinton and R. Salakhutdinov, "Reducing the dimensionality of data with neural networks," Science, vol. 313(5786), pp. 504–507, 2006.

[16] Tenenbaum, J.B., de Silva, V. & Langford, J.C (2000) A global geometric framework for nonlinear dimensionality reduction. Science 290: 2319–2323.

[17] Blei D. M., Ng A. Y. and Jordan M. I., ”Latent Dirichlet Allocation”. Journal of Machine Learning Research, 3, pp. 993-1022, 2003.

[18] F. Benčić, S. Nemet, M. Barać, D. Kukolj, Trends in AI based Automotive Industry using Patent Analysis, 26th TELFOR 2018, Belgrade, Nov. 20-21, 2018.

[19] H. C. Wu, R. W. P. Luk, K. F. Wong, and K. L. Kwok., Interpreting TF–IDF Term Weights as Making Relevance Decisions. ACM Transactions on Information Systems 26(3):1-37, 2008.

[20] A. Jegede, Top 10 best refrigerator brands in the world, online at: www.trendrr.net/10999/.