Virtual DNA (V-DNA) Applications: A Systematic Literature Review

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Abstract

Considering organization, manufacturing unit or products as a living organism and develop related DNA is one of research areas that attracted researchers over the years. Actually, a variety of research directions and different applications is identifiable in the literature. Therefore, a systematic literature review conducted and Virtual DNA (V-DNA) applications' diagram proposed. Based on the proposed diagram, V-DNA research areas classified to three main research areas namely Organization DNA (O-DNA), Manufacturing DNA (M-DNA), and Decisional-DNA (D-DNA). For each one of those research areas, a list of applications presented based on the reviewed literature. Furthermore, a list of future research directions extracted from the most recent papers and summarized in the synthesis section. Authors in the current research suggested to expand the research efforts in all DNAs research areas and try to integrate those efforts to create a comprehensive DNA that encompass all organization levels, from product all the way to the highest level of the organization considering the necessary correlations between all units and levels, to ensure establishment of improvement projects and take decisions' able to maximize organization performance and avoid the contradictions coming from improvements that may improve one area but has a negative impact on other areas.

Keywords

Virtual; Organizational; Decisional; Corporate; DNA

1. Introduction

DNA, or deoxyribonucleic acid, is "*the hereditary material in humans and almost all other organisms*". Each organism consists of trillions of cells, in each cell, in the nucleus of the cell, each organism has a set of chromosomes, and human has 23 pairs of chromosomes. Each chromosomes contains many genes, and each gene made up of DNAs. DNA presented in the literature as a double helix, see Figure.1, and it is consist of chemical bases and other components. DNA contains all organism features, i.e. length, color, sex, eye color, hair color….etc. which organism got from his parents' DNAs (Genetics Home Reference, 2017). For humans or any other organism, it happens that some genes will have some changes, positive or negative, from the standard genes, which lead sometime to disorders in the organism features, e.g. genetic diseases, recessive traits, and congenital disorders. Therefore, Genetic engineering (GE) science developed. GE is "*a set of techniques for isolating, modifying, multiplying and recombining genes from different organisms, genetic engineering science has been developed to reform consciously the chromosomes for living beings to accentuate good characteristics or to clone living beings according to their chromosomes*", see references there in (Chen and Feng, 2003).

Virtual DNA (V-DNA) approach has been used in the literature in different scopes. E.g. *Organizational DNA* terminology has been used in the literature to describe organization elements namely organization structure, organization members, organization systems, and organization culture. The structure element may contain reporting structure, information flows, decision process, and process flows. Members element related to all staff aspects. Systems element related to organization performance system, control systems…. etc. and culture element related to organization behaviors and values (Carroll, 2016), page 520-521. Carroll (2016), in the pages 520-521, stated that organizational DNA was used in very unspecific way and it needs to be unpacked. *Organizational DNA* can be defined as a "*metaphor that is used to describe the essence of an organization's identity"* (Carroll, 2016), page 520. V-DNA has been used as well to describe the mechanical products design and its optimization process (Chen and Feng, 2004; Chen, Feng and Chen, 2005), and to develop knowledge structure assist organization to develop "*Virtual Engineering Object (VEO), Virtual Engineering Process (VEP) and Virtual Engineering Factory (VEF)*" (Shafiq, Sanin, Szczerbicki, *et al.*, 2016; Sanin *et al.*, 2017). Therefore, the objectives of this paper is identify the applications of V-DNA approach in the state of the art literature, and the future research directions. Thus, a systematic literature review process will be conducted.

In the current research, based on the systematic literature review, V-DNA research areas and applications available in the literature analyzed critically. After that, a diagram of V-DNA research areas and its related applications proposed. Moreover, an insight about future research directions presented. This paper is structured as follows: first, research motivations outlined; second, research questions devised; third, research methodology explained; fourth, literature

review conducted; fifth, the final paper contributions discussed in the discussion section; sixth, research implications outlined; finally, conclusions presented in the conclusions section.

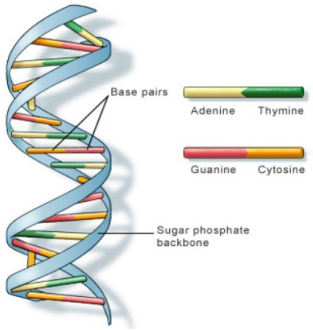

Figure1: DNA double helix (Genetics Home Reference, 2017)

2. Research questions

To guide the systematic literature review process stated in the previous section and ensure research objectives fulfillment, the following research questions derived:

- Q1: What are the current applications of V-DNA in the state of the art literature?
- Q2: What are the future research directions in the V-DNA scope?

3. Research Methodology

The systematic literature review methodology used in this paper used in Crossan and Apaydin (2010) to conduct systematic literature review. In the Crossan and Apaydin methodology, the literature review process divided to three steps namely; data collection, results' analysis, and results' synthesis. Research methodology shown in the Figure.2. In-addition, systematic literature review steps described in the following points (Crossan and Apaydin, 2010):

3.1 Step-1-Data Collection:

In this step, the systematic literature review methodology used by Tranfield, Denyer and Smart (2003) will be used. In this methodology, data collection step will be conducted in three steps namely literature review planning, literature review execution, and literature review reporting.

3.2 Step-2-Results' Analysis:

In this step, the selected publications will be analyzed to identify applications of V-DNA and the future research directions.

3.3 Step-3-Results' Synthesis:

Literature review analysis results will be synthesized in this step to summarize it and build insights about V-DNA applications and future research directions.

4. Literature Review

4.1 Step-1-Data Collection:

The actions to be taken in this step will be as follow:

4.1.1 Literature Review Planning

4.1.1.1 Defining Literature Review Objectives

The objectives of this literature review is to answer the research questions related to V-DNA applications and future research directions.

4.1.1.2 Publication Type Selection

Peer reviewed publications will be targeted in this literature review to maintain highest level of literature review results' quality.

4.1.1.3 Online Databases Selection

Google scholar database will be used in this literature review. Google scholar database assist researchers to access wide spectrum of rigor scientific journals, and access other papers cited by or cites the selected papers.

4.1.1.4 Keywords Selection

The keywords "Virtual", "Organizational", "Decisional", "Corporate", and "DNA" will be used in this literature review.

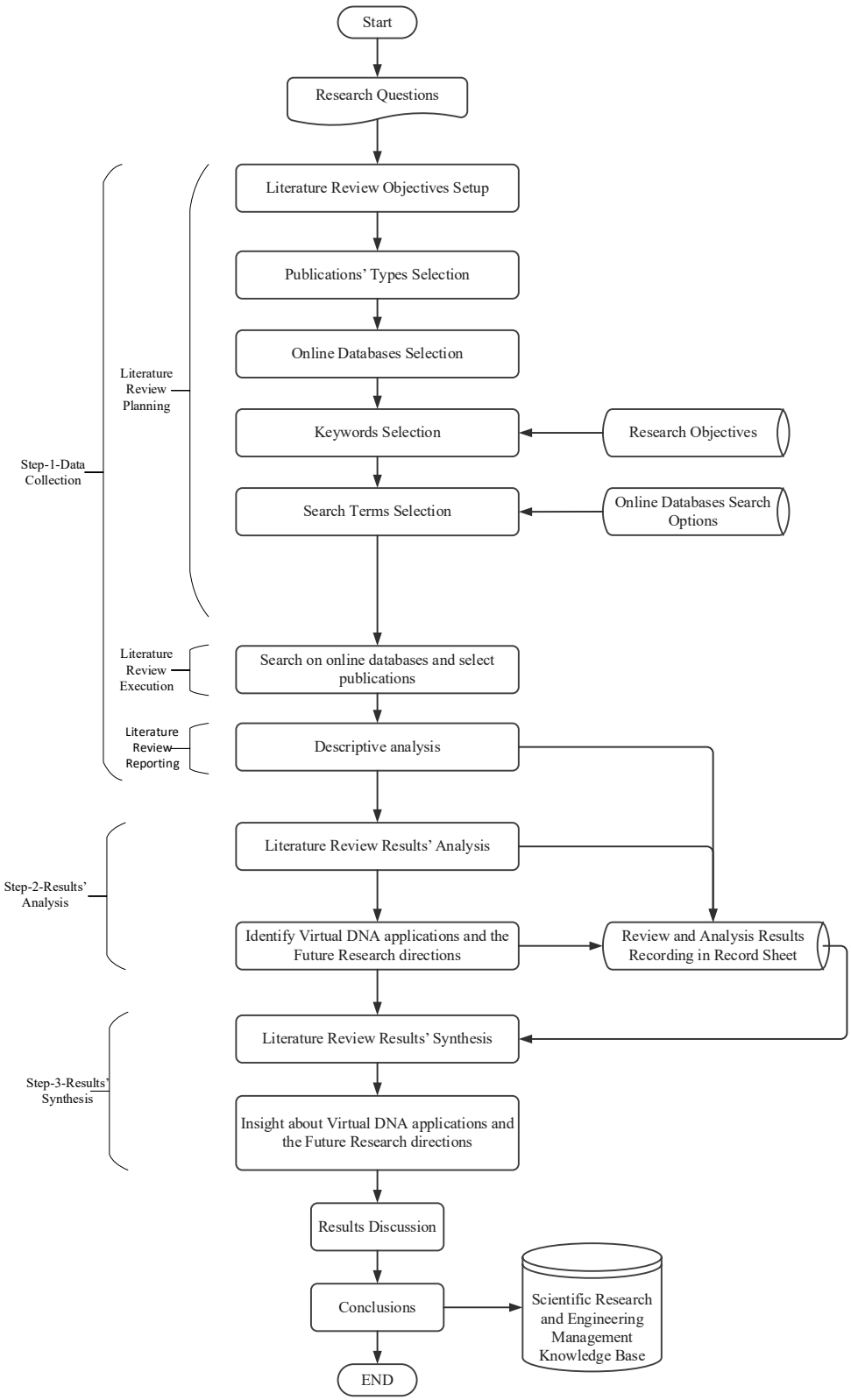

Figure 2: Research methodology

4.1.1.5 Search Terms Identification

The following search terms used to limit the literature search to find relevant publications only:

1. Literature review will be limited to 20 years back from the date of writing this paper.

2. Out of all publications types, only academic journal articles and conference papers will be selected for review to ensure high quality results from review process.
3. Only publications published in English language will be accepted in this literature review.
4. Only publications in the scope of Engineering and Business Management will be accepted.

4.1.2 Literature Review Execution

The search in the Google scholar database, after excluding all irrelevant publications, resulted a list of (29) journal articles and (17) conference papers. Almost 63% of the selected publications were peer reviewed articles which gives indicates about the high quality of the selected publications. On the other hand, 37% of the selected publications were conference papers which indicates that V-DNA topic are still one of the hot topics in the scientific research community.

4.1.3 Literature Review Reporting

The selected publications distributed between the years 2002 and 2018, 16 years, with 50% of publications published after 2013, which indicates the novelty of V-DNA topic, see Figure.3. Journal articles distributed among (19) journals as shown in the Figure.4, which express the high diversity of the selected articles from academic journals and ensure inclusion of wide range of researchers' contributions. Regarding business sectors, the selected publications were distributed among educational sector 2%, health care sector 2%, general industrial sector 53%, specifically manufacturing sector 44%, Non-profit organizations 2%, tourism sector 4%, and 37% of the selected publications were directed to serve all sectors, i.e. general. The reader of these numbers can conclude that V-DNA topic has diversity and used in most of business sectors and specifically for industrial sector as its clear in the Figure.5 , i.e. majority of publications were directed to industrial sector. Categorizing the selected publications by authors' country reveals that majority of papers, 35%, were published by authors from different countries, i.e. international collaboration, mainly between authors from Australia, Poland, and Spain. Authors from China published 24% of publications, 15% of the publications were published by authors from USA, then authors from other countries will follow, see Figure.6. The above statement showed the importance of V-DNA research scope, which represented by authors' international collaboration and publications published by authors from biggest economies over the world, i.e. USA and China. The above conclusions can be further supported by looking to the authors' countries. As its shown in the Figure.7, authors' countries categorized to developed countries, developing countries, and international collaboration (54% of authors' countries were from developed countries, 35% of publications published through international collaboration's research but majority of collaborated researchers were from developed countries, and only 11% authors were from developing countries).

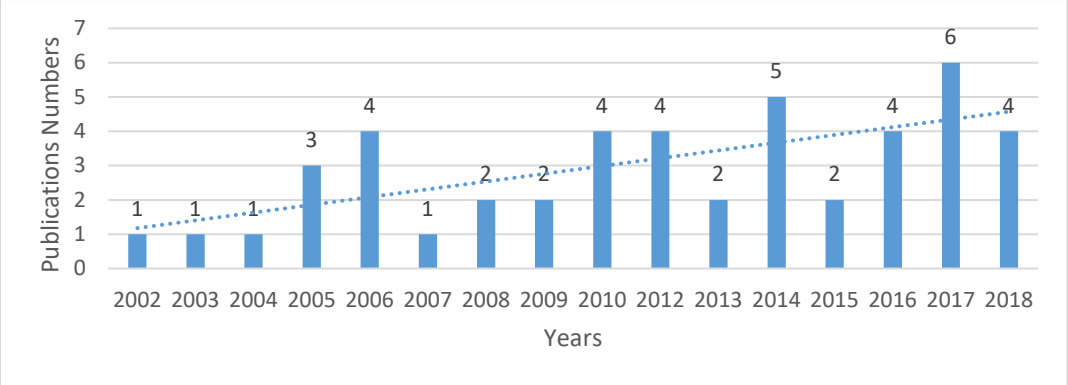

Figure 3: Publications distribution over the years

4.2 Step-2-Results' Analysis:

The review of the V-DNA state of the art literature reveals identification of three main DNAs' research areas namely DNAs related to the research directed to the manufacturing systems' analysis, optimization, and improve factory units' efficiency, DNAs related to the research directed to the organizations/corporates/enterprises' change, culture, ethics…. etc., and DNAs related to the research directed to the knowledge representation, knowledge structure management, and to enhance decision making process (Decisional DNA).

In the current research, for DNAs' research areas mentioned in the above statement, the following Shortcuts will be used:

- The first area of the DNAs, manufacturing systems' DNA, (M-DNA) will be used.
- The second area, Organizational DNA, (O-DNA) will be used.
- The third area, Decisional DNA, (D-DNA) will be used.

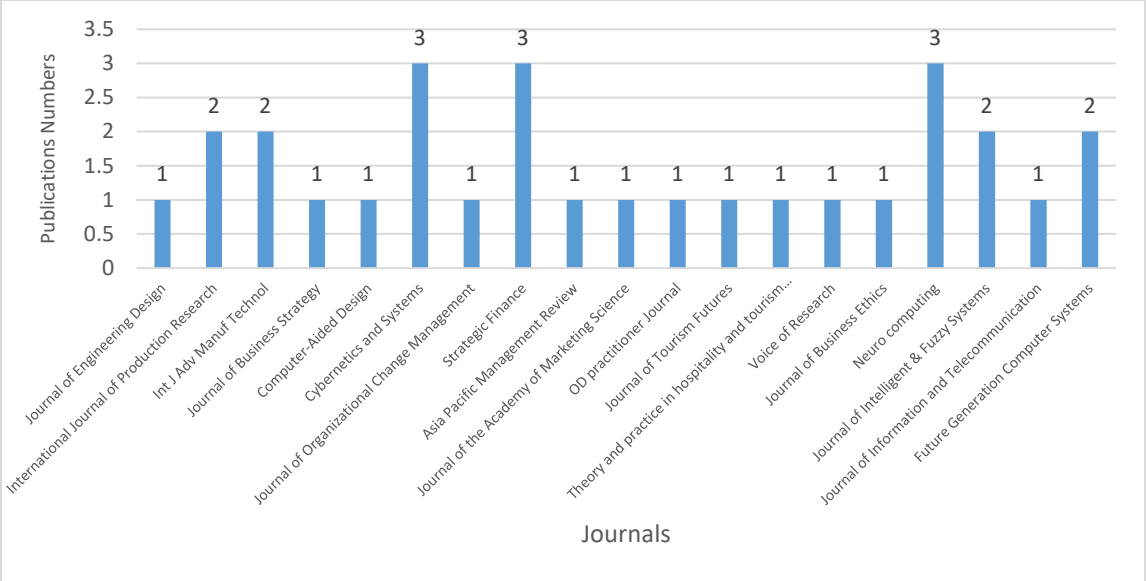

Figure 4: Journal Articles' distribution among journals

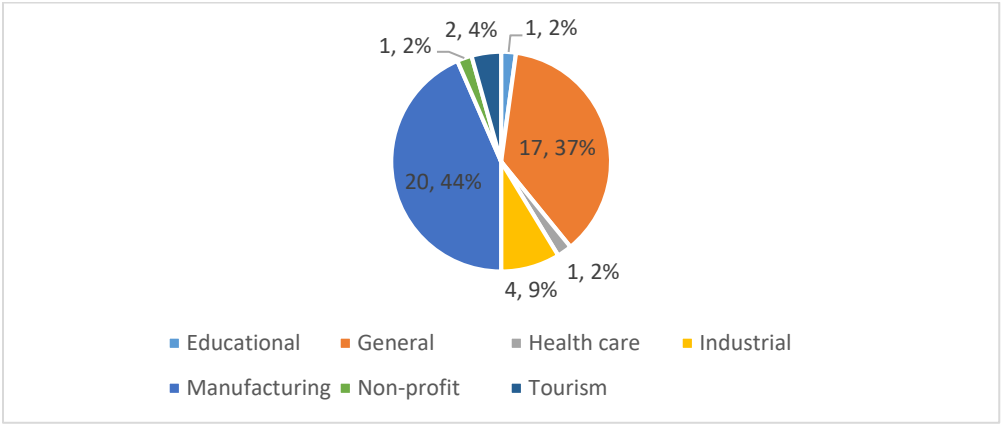

Figure 5: Publications distribution by business sector

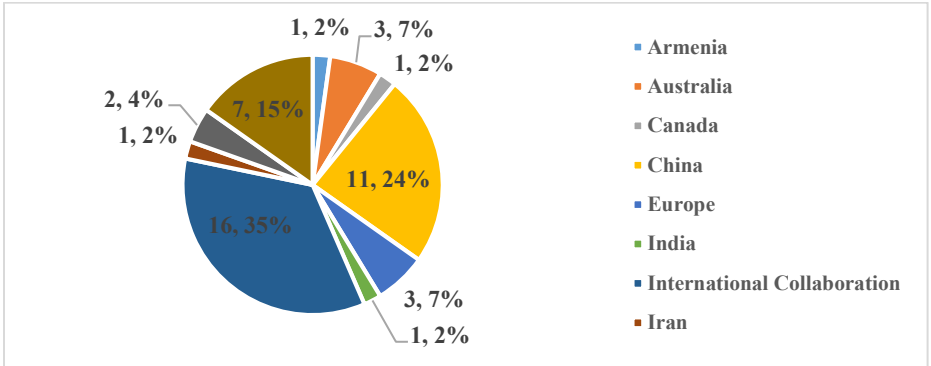

Figure 6: Publications distribution by authors' country

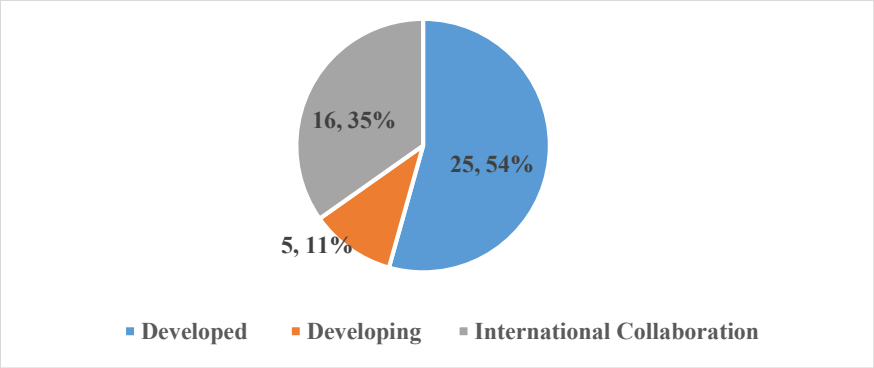

Figure 7: Publications distribution by authors' country catigory

Based on the reviewed literature, the applications of V-DNA in the state of the art literature related to M-DNA will be as follows:

1. V-DNA concept used in Mechanical Product Design Theory and specifically in Product Innovation (Chen and Feng, 2003), (Chen and Feng, 2009), (Chen, Feng and Chen, 2005), e.g. product design theory used for distribution of sea rescue appliances designed by use of the accident data and experience (Chen *et al.*, 2010). Moreover, product genes and its structure developed by designing products based on surface functions features (Chen *et al.*, 2006). After that, following to the development of designing product genes and its structure based on surface functions Product Growth Design platform (DARFAD) system introduced (Chen *et al.*, 2007).
2. Quality genes developed for quality information in the manufacturing process to detect the similarity between the detected product quality gene and the case genes in order to check if product quality is normal (Sun *et al.*, 2013).
3. V-DNA approach used to study and create product design process gene and its structure (Li, Tong and Shi, 2010). In addition, to find the best product design solution and maintain continuous improvement in product design process, V-DNA approach used to create Auto Genetic Design Theory (ADT) for evolutionary based product design (Kittel and Vajna, 2009).
4. An evolutionary tolerance design strategy developed based on Product Gene (PG) engineering approach and product growth design (Yang et al., 2013).
5. V-DNA approach used for mechanical part type selection and to solve machine loading problem in flexible manufacturing system (FMS) (Yang and Wu, 2002).
6. V-DNA approach used to create Technology DNA (T-DNA). T-DNA is an approach used to monitor, analyze and identify the of individual characteristics for technological fields based on the patents' data (Roepke and Moehrle, 2012).

For O-DNA area, based on the reviewed literature, the applications of V-DNA in the state of the art literature related to O-DNA will be as follows:

1. Based on V-DNA approach, Innovation DNA defined and created to promote a sustainable competitive advantage of organization (Dobni, 2008).
2. O-DNA along with other two constructs developed to create market-oriented to sustainability framework to incorporate sustainability in the market orientation. The developed O-DNA consist of core ideology, dynamic capabilities, and societal engagement (Crittenden *et al.*, 2011).
3. In the research scope related to business sustainability, four types of O-DNA presented by Postma, Cavagnaro and Spruyt (2017) to assist organizations in tourism sector to adopt sustainability principles in their business by 2040. In addition, the impact of O-DNA along with other two factors on the Management Accounting Practices (MAPs) studied to identify the MAPs' development stage in Small and Medium-size Enterprises (SMEs) in Malaysia. The objective was improving SMEs' cost efficiency to improve business sustainability (Azudin and Mansor, 2017), (Kordlouie and Hosseinpour, 2018).
4. O-DNA term used to describe a list of simple rules derived to create positive organizational change (Holladay, 2005). Actually, O-DNA used in organizational change scope and exactly in organizations' re-engineering due to merger and acquisition. Based on O-DNA, five O-DNAs' models identified namely "People-centric Model, Molecular Model, Kaizen – Lean Six Sigma Model, Globally Dispersed Model, and Disaggregated Value Chained Model", to assist practitioners and organizations to create a Pentatomic Organization model based on the pentatomic framework developed from the DNAs' models stated in above, in order to address challenges arises with 21st century business environment (Mo and Chattophdhyay, 2012). In-addition, O-DNA term used to

describe the improvement models used for organizational change (Mertkan and Sugrue, 2014). O-DNA building blocks namely *Decision Rights, Information, Motivators, and structure* used to change organization system which will change organization culture, in order to improve organization adaptability and flexibility to improve organization competitiveness (Venkatesh and Chenrui, 2015) and (Chehade, Mendes and Mitchell, 2006).
5. O-DNA term used to discuss ethics role in organization culture (Verschoor, 2004) and (Verschoor, 2005).
6. O-DNA theory used to study the effect of organization size and culture on the organization health/ performance (LENA H. HOVIVYAN, 2006).
7. O-DNA used to study the defects-creating structures of the organizations and suggest a framework to detect organizational structures prone to produce defective products and services (Ivanov, 2012).
8. O-DNA types and its strengths reviewed, and then used to study the Human Resource Practice (HRP) patterns in the hotels is aligned with which O-DNA type and the effect of those patterns on hotels' performance (Z.N. Aishah *et al.*, 2015).
9. Ethical O-DNA used in Risk-based approach to create an optimal balance between rules-based and principles-based approaches for organization governance as a way forward for effective corporate governance in order to sustain organization competitive advantage and improve organization performance (Arjoon, 2006).

And for D-DNA area, based on the reviewed literature, the applications of V-DNA in the state of the art literature related to D-DNA will be as follows:

1. Set of Experience Knowledge Structure (SOEKS) and D-DNA used to propose a Smart Innovation Engineering System. The proposed system is semi-automatic system used knowledge and experiences in product innovation process (Arjoon, 2006), (Waris, Sanin and Szczerbicki, 2018). Same authors conduct further development on the D-DNA and developed a smart knowledge management system to create systematic and dynamic product innovation process (Waris, Sanin and Szczerbicki, 2016b), (Waris, Sanin and Szczerbicki, 2016a). Furthermore, D-DNA used with Cognitive Embedded Systems to make them able to acquire, reuse, evolve and share knowledge in more efficient way (Haoxi Zhang, Sanin and Szczerbicki, 2010). In similar fashion, Neural Knowledge DNA (NK-DNA) concept presented based on Neural Network tool usage in knowledge representation. Neural Knowledge DNA is designed to "*support discovering, storing, reusing, improving, and sharing knowledge among machines, computing devices, and organizations*" (Zhang *et al.*, 2017).
2. V-DNA approach used to develop the concept of Virtual Engineering Object (VEO), VEO is *"the knowledge representation of an engineering object, having embodiment of all its associated knowledge and experience within it"*. then it was powered by SOEKS and D-DNA to improve decision making process in industrial design process and manufacturing units (Shafiq *et al.*, 2014). VEO work then extended to develop a Virtual Engineering Process (VEP), VEP is *"experience-based knowledge representation of engineering processes"*. VEP powered by D-DNA and SOEKS used for knowledge representation of engineering processes and all related information about machines, engineering objects, resources, manufacturing operations, and decisions that has been taken before to enhance and improve decisions' quality and manufacturing systems' performance (Shafiq, Sanin, Toro, *et al.*, 2016).
3. SOEKS, D-DNA used to propose a Virtual Engineering Factory (VEF), based on VEO and VEP, as last stage to develop the "Complete Virtual Manufacturing Environment". VEF is *"an experience based knowledge representation for a factory encompassing VEP and VEO within it"*. The developed model will enhance the knowledge representation, decision making process in all factory levels, and expand intelligence for future production (Shafiq *et al.*, 2017). Same authors proposed Intelligent Factory framework based on VEO, VEP, SOEKS, D-DNA. The proposed framework able to analyze engineering objects and manufacturing process, monitor performance, and take decisions for a smart manufacturing environment (Shafiq, Velez, *et al.*, 2016).
4. VEO, VEP, SOEKS, D-DNA, and VEF used to propose and test a collective knowledge structures through a set of case studies. The proposed knowledge structures represent is a "practical standards for engineering collective intelligence" (Sanin *et al.*, 2017).
5. To develop an intelligent Computer Integrated Manufacturing (CIM) that ready and can be used in virtual Industry 4.0 environment, VEO, and VEP used to propose a D-DNA based knowledge representation framework. The proposed framework used to manage CIM components by capturing, storing, analyzing, and processing data and information related to those components (Shafiq, Szczerbicki and Sanin, 2018).
6. D-DNA used to support decision making processes on organizations and to predict organization capabilities (Sanin *et al.*, 2012).
7. D-DNA, SOEKS, and an evolutionary algorithm used to solve optimization problems that have two or more objectives that conflict with each other (Wang, Sanin and Szczerbicki, 2015).
8. D-DNA, SOEKS, and other algorithms used to propose a semi-automatic update process of the underlying knowledge bases and decision criteria of Clinical Decision Support Systems (CDSS) (Sanchez *et al.*, 2014).

9. D-DNA, Reflexive Ontologies, and security technologies used to propose a Decisional Trust System (DTS). The proposed system will improve users' reliance on the knowledge system decisions (Sanin and Szczerbicki, 2008).
10. The viability of using a D-DNA, and SOEKS in robotics control tested and proved (Sheffer, Sanin and Szczerbicki, 2014).
11. Based on D-DNA, a multi-domain knowledge structure based on experience developed and implemented as a "comprehensive embedded knowledge representation for Internet of Things (IOT) and Cyber Physical Systems (CPS)". The proposed knowledge structure tested in many case studies and proved that it can improve and enhance IOT and CPS technologies and it has many benefits (Sanin *et al.*, 2018).

Regarding future research directions, authors were able to identify many research directions in the reviewed literature. However, authors will summarize the future research directions stated in the papers published after 2015 in the synthesis section. The logic of this decision is that usually researchers set a future research directions mentioned in their papers as a next research projects in their agenda. Therefore, any future research directions stated in the papers' published before 2015 will be an old projects and it may be already fulfilled.

4.3 Step-3-Results' Synthesis:

In this section, authors will synthesize the results analyzed and discussed in the previous sections in order to answer research questions. Therefore, based on the results analysis the answers of the research questions will be as follows:

- Q1: What are the current applications of V-DNA in the state of the art literature?

A diagram of V-DNA applications derived to give insight to researchers about the current V-DNA applications and guide research efforts to target areas that may need further development. Based on analysis conducted on the literature review results, V-DNA applications can be classified to three main areas namely M-DNA, O-DNA, and D-DNA.

M-DNA approach used for DNAs related to products' design theory, i.e. design growth theory and its related applications namely product innovation DNA, product quality information DNA, product design process DNA, product tolerances' design DNA, and technology DNA. The difference between product innovation DNA and product design process DNA is that former concerned with product parts and elements and the latter concerned with elements of design process rather than product itself. All DNAs classified under M-DNA used to optimize manufacturing units' processes from mechanical products' elements point of view, especially part type selection and machines loading in FMS.

O-DNA approach used in all applications related to organization's culture, efficiency, performance, sustainability…etc. Therefore, O-DNA applications, based on analysis results, includes; DNAs related to innovation process on organization level, DNAs related to organization's sustainability either in market orientation or business model, and DNA related to conducting positive organization change. O-DNA approach used as well to develop DNAs' related to organization culture and its related issues of managing e.g. ethics issues, human resource management, etc., and for organization performance and organizations' structures prone to produce defective products and services O-DNAs used as well.

D-DNA approach used in all applications related to knowledge and experiences capturing, analyzing, storing, and use to support decision-making process and optimize organization's performance. D-DNA applications includes; smart knowledge management systems, develop a VEF and its related VEO and VEP, create smart manufacturing environment, use D-DNA in creating advanced CIM factories for virtual Industry 4.0 environment. Furthermore, D-DNA used to predict organization capabilities, to conduct optimization on organization level, creation of Decision Support Systems (DSS) and Decisional Trust System (DTS), use of D-DNA in robotics control scope, and to develop multi-domain knowledge structures to use for IOT and CPS.

The difference between M-DNA and D-DNA that M-DNA, as it was stated before, optimizing products, processes, and manufacturing units only, and it depends on testing possible objects/ elements combinations and possible alternative solutions to optimize products and its related elements, e.g. tolerance, quality information …etc. in order to maximize manufacturing units' efficiency. On the other hand, D-DNA deal with manufacturing systems from higher level and it depends on accumulated knowledge and experience to optimize decision making process efficiency and accuracy, and enhance manufacturing systems' performance. V-DNA applications' diagram shown in the Figure.8.

- Q2: What are the future research directions in the V-DNA scope?

For future research extracted from reviewed literature, it has been noticed that in M-DNA area the most recent paper, reviewed in the current paper, was published in 2013 year. Therefore, future research directions stated on those papers, based in the criterion set in the analysis section, will not be considered in the current paper. However, in the work of Roepke and Moehrle (2012) *"Characterizing the Evolution of Technologies: An Introduction of Technology-DNA",* which was published in 2012, authors stated that in future work, T-DNA approach can be used for future *to monitor the evolution of technological fields, analyze the types of innovations and its impact on the structure of T-DNA, and Generate T-DNA for firms to detect their inventive profiles and compare it with T-DNA of its "associated technological*

field to ensure firm's conformance with the general developments in the field", which represent a valuable research direction that not yet tackled based on the current paper literature review.
For D-DNA area, it has been noticed that most of research directions stated in the papers published after 2015 year were focused on refining and improving the current DNAs' models or developing a new DNAs' models to serve new industry paradigm, i.e. industry 4.0.
For O-DNA area, most of future work directions were focused on improving organizations' performance and its related research problems. However, only future research directions stated in the papers published after 2015 year included in the current paper. See Table 1 for the most recent research directions.

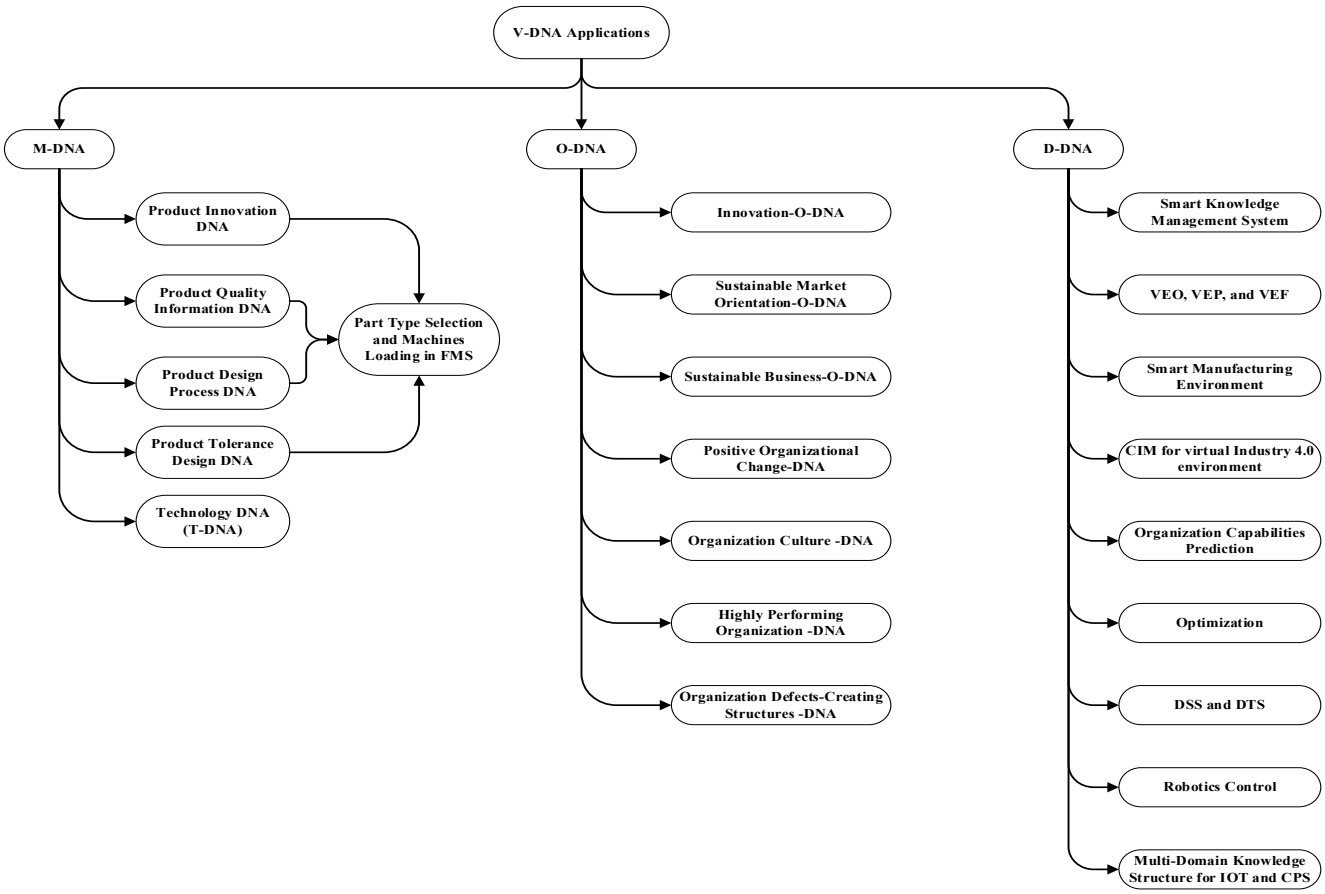

Figure 8: V-DNA Applications' Diagram

5. Discussion

The objectives of this research is to identify the applications of V-DNA approach in the state of the art literature, and the future research directions. Therefore, research questions derived, systematic literature review conducted, and research questions answered based on the literature review results' analysis and synthesis. It has been proved in this literature review that V-DNA approach has wide spectrum of applications which mainly divided to M-DNA, O-DNA, and D-DNA research areas. However, it has been noticed that M-DNA area was limited to the manufacturing unit level and the most recent published paper was on 2013 compare to other areas, O-DNA and D-DNA, which focus on higher levels and they still hot research areas. Actually, most of the published papers in the D-DNA research area were published to contribute in the development of new industry paradigm namely industry 4.0.
To answer the second research question, future research directions extracted from reviewed papers and summarized in the synthesis section. *However, authors in the current paper suggest to expand the research efforts in all DNAs research areas and try to integrate those efforts to create a comprehensive DNA that encompass all organization levels, from product all the way to the highest level of the organization considering the necessary correlations between all units and levels, to ensure establishment of improvement projects and take decisions' able to maximize organization*

performance and avoid the contradictions coming from improvements that may improve one area but has a negative impact on other areas.

Table 1: Future Research directions

Sr.	DNA Area	Reference	Publication Year	Future Research Gaps
1	D-DNA	(Shafiq, Sanin, Toro, *et al.*, 2016)	2016	Develop a network of Virtual Engineering Objects (VEOs) and test the VEP technique in the real-life processes.
2		(Shafiq, Velez, *et al.*, 2016)	2016	For Industry 4.0 , Intelligent Factory framework play a vital role for developing and implementing industry 4.0 architecture.
3		(Shafiq *et al.*, 2017)	2017	Future work will be directed to create a network of manufacturing DNAs and integrate them in order to share and transfer knowledge among different manufacturing set-ups in order to meet future requirements of cyber-physical systems.
4		(Zhang *et al.*, 2017)	2017	Future work directed to refine and improve Neural network DNA and develop a "Deep Learning Engine".
5	O-DNA	(Azudin and Mansor, 2017), (Kordlouie and Hosseinpour, 2018)	2017,2018	Future work should be directed to study the Management Accounting Practices (MAPs) and its impact on organizations' efficiency and sustainability to improve organizations performance.

6. Research Implications

The research has both theoretical and practical implications. For theoretical implications, an insight about V-DNA applications and future research directions shared in this paper with researchers, which may guide future research efforts. For practical implications, the proposed V-DNA applications' diagram can assist practitioners to classify their development projects and manage it from strategic level. Some real life cases extracted from literature shown in the table 2.

Table 2: Real life cases of V-DNA applications

Sr.	DNA Area	Reference	Real life case
1	M-DNA	(Chen and Feng, 2009)	Designing Ball Bearing with optimized performance
2		(Yang *et al.*, 2013)	Clamping tool used for precision boring of a plunger pinhole
3	D-DNA	(Haoxi Zhang, Sanin and Szczerbicki, 2010)	Cognitive Embedded Systems
4		(Sanin *et al.*, 2012)	Interactive television, "*an evolutionary integration of the Internet and Digital TV*"
5	O-DNA	(LENA H. HOVIVYAN, 2006)	Merger and acquisition of organization, e.g. GEW case.
6		(Azudin and Mansor, 2017)	Management Accounting Practices development stage in Small and Medium-size Enterprises (SMEs) in Malaysia

7. Conclusions

Looking to organization/ manufacturing units/ product as living organism and develop related DNA to describe their structure and analyze it to propose optimized solutions and improve performance are one of the research areas that attracted researchers over the years, which resulted a variety of research directions and different applications. Therefore, a systematic literature review conducted and V-DNA applications' diagram proposed. Based on the proposed diagram, V-DNA research areas classified to three main research areas namely M-DNA, O-DNA, and D-DNA. For each one of those research areas, a list of applications presented based on the reviewed literature. Furthermore, a list of future research directions extracted from the most recent papers and summarized in the synthesis section. However, authors in the current paper suggested to expand the research efforts in all DNAs research areas and try to integrate those efforts to create a comprehensive DNA that encompass all organization levels, from product all the way to the highest level of the organization considering the necessary correlations between all units and levels, to ensure establishment of improvement projects and take decisions' able to maximize organization performance and avoid the contradictions coming from improvements that may improve one area but has a negative impact on other areas.

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