

# INTERDISCIPLINARY DESCRIPTION OF COMPLEX SYSTEMS

**Scientific Journal**

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## Scientific Journal

# INTERDISCIPLINARY DESCRIPTION OF COMPLEX SYSTEMS

INDECS, volume 15, issue 3, pages 174-227, year 2017

Published 24<sup>th</sup> October 2017 in Zagreb, Croatia

Released online 24<sup>th</sup> October 2017

### Office

Croatian Interdisciplinary Society

c/o Faculty of Mechanical Engineering & Naval Architecture

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Published by Croatian Interdisciplinary Society (<http://www.idd.hr>) quarterly as printed (ISSN 1334-4684) and online (ISSN 1334-4676) edition. Printed by Redak d.o.o. (HR) in 50 pieces. Online edition, <http://indecs.eu>, contains freely available full texts of published articles.

Journal INDECS is financially supported by Croatian Ministry of Science and Education.

Content of the journal INDECS is included in the DOAJ, EBSCO, EconLit, ERIH PLUS, Ulrich's and Web of Science Core Collection.

INDECS publishes original, peer-reviewed, scientific contributions prepared as reviews, regular articles and conference papers, brief and preliminary reports and comments to published articles. Manuscripts are automatically processed with the system Comet, see details here: <http://journal.sdewes.org/indecs>.

The accessibility of all URLs in the texts was checked one week before the publishing date.

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# RANKING BALTIC STATES RESEARCHERS

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DOI: 10.7906/indecs.15.3.1  
Regular article

Received: 10<sup>th</sup> July 2017.  
Accepted: 25<sup>th</sup> September 2017.

## ABSTRACT

In this article, using the h-index and the total number of citations, the best 10 Lithuanian, Latvian and Estonian researchers from several disciplines are ranked. The list may be formed based on the h-index and the total number of citations, given in Web of Science, Scopus, Publish or Perish Program and Google Scholar database. Data for the first 10 researchers are presented. Google Scholar is the most complete. Therefore, to define a single indicator, h-index calculated by Google Scholar may be a good and simple one. The author chooses the Google Scholar database as it is the broadest one.

## KEY WORDS

ranking Baltic states researchers, Lithuanian, Latvian and Estonian researchers, h-index, number of citations, Google Scholar database

## CLASSIFICATION

ACM: D.1.1.

JEL: O31

PACS: 89.70.Hj

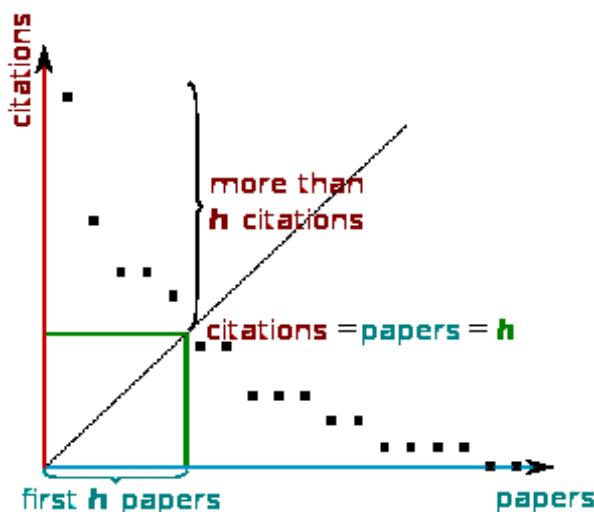
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## INTRODUCTION

The Academic Ranking of World Universities (ARWU) was first published in June 2003 by the Center for World-Class Universities (CWCU), Graduate School of Education (formerly the Institute of Higher Education) of Shanghai Jiao Tong University, China [1]. Due to the requests in a variety of activities ranking researchers in different disciplines of science become very important in last decade. Ranking is possible on different criteria: number of published articles, number of citations, h-index, g-index, etc.

One of these measures is h-index which includes both the productivity and citation impact of the publications of a scientist. The index was suggested in 2005 by Jorge E. Hirsch [2]:

“A scientist has index  $h$  if  $h$  of his/her  $N_p$  papers have at least  $h$  citations each, and the other  $(N_p - h)$  papers have no more than  $h$  citations each.” (Figure 1.)



**Figure 1.** Graphical presentation of h-index.

h-index can be determined according to the different sources:

- Google Scholar,
- WOS (Web of Science),
- Scopus,
- Publish or Perish Program.

In this article the list of the best 10 Lithuanian, Latvian and Estonian (three Baltic states) researchers from several disciplines is ranked. List covers researchers from natural sciences, techniques and human sciences.

**Table 1.** Rate of citations in Scopus and Web of Science according to Google Scholar ones.

Discipline	Scopus citations as percentage of Google Scholar citations, %	Web of Science citations as percentage of Google Scholar citations, %
Humanities	11,5	7,0
Social Sciences	30,0	22,7
Engineering	57,6	45,7
Sciences	64,2	65,6
Life Sciences	70,5	66,8

As a primary source Google Scholar [3] has been used [4-25]. The author chooses the Google Scholar database as it is the widest (see Table 1). Introduced by Google in 2004, Google Scholar has become a very popular alternative data source. Google Scholar is the most complete. Therefore, to define a single indicator, h-index calculated by Google Scholar may be a good and simple one. Ranking is possible to be based on h-index (primary) and total number of citations.

The article is organized as follows:

in Section 1 the Introduction is given,

in Section 2 the Ranking list of best 10 Lithuanian researchers,

in Section 3 the Ranking list of best 10 Latvian researchers,

in Section 4 the Ranking list of best 10 Estonian researchers is considered.

Conclusions are given in Section 5.

## RANKING LIST OF THE BEST 10 LITHUANIAN RESEARCHERS

In the following text detail information about Lithuanian researchers on the list based on Google Scholar are presented [26]. List of 10 best Lithuanian researchers can be constructed based on different sources. The primary condition for ranking is the h-index and the total citation number of the publications.

Researchers, from Google Scholar data, were ranked according h-index in decreasing order as a first criteria and then by the total number of citations (Table 2).

**Table 2.** Ranking list of best 10 Lithuanian researchers from several disciplines, from Google Scholar.

No.	Researchers	h-index	Citations
1.	Edmundas K. Zavadskas	62	13 681
2.	Algirdas Avižienis	45	16 143
3.	Arunas Ramanavicius	41	5 572
4.	Zenonas Turskis	39	5 400
5.	Artūras Kaklauskas	35	4 840
6.	Saulius Klimašauskas	33	4 733
7.	Kestutis Pyragas	29	8 087
8.	Česlovas Venclovas	28	3 073
9.	Arunas Krotkus	27	2 829
10.	Gintaras Valušis	27	2 718

## RANKING LIST OF THE BEST 10 LATVIAN RESEARCHERS

In the following text detail information about Latvian researchers on the list based on Google Scholar are presented [27]. Latvian Researchers, from Google Scholar data, were ranked according h-index in decreasing order as a first criteria and then by the total number of citations (Table 3).

## RANKING LIST OF THE BEST 10 ESTONIAN RESEARCHERS

In the following text detail information about Estonian researchers on the list based on Google Scholar are presented [28].

Estonian Researchers, from Google Scholar data, were ranked according h-index in decreasing order as a first criteria and then by the total number of citations (Table 4).

**Table 3.** Ranking list of best 10 Latvian researchers from several disciplines, from Google Scholar.

No.	Researcher	h-index	Citations
1.	Eugene Kotomin	49	8 855
2.	Susanne Iwarsson	46	7 340
3.	Andris Ambainis	38	7 028
4.	Alexei Kuzmin	31	3 240
5.	Juris Purans	30	2 674
6.	Janis Klovins	27	3 610
7.	Indrikis Krams	27	2 081
8.	Rusins Freivalds	26	3 029
9.	Anatoly Trukhin	25	2 080
10.	Andris Auliciems	23	2 051

**Table 4.** Ranking list of best 10 Estonian researchers from several disciplines, from Google Scholar.

No.	Researcher	h-index	Citations
1.	Risto Näätänen	124	58 489
2.	Martti Raidal	121	76 095
3.	Andres Metspalu	84	31 373
4.	Ülo Niinemets	75	23 336
5.	Tõnu Esko	63	24 177
6.	Marlon Dumas	63	21 738
7.	Martin Zobel	62	15 922
8.	Jüri Allik	55	15 456
9.	Reedik Mägi	52	17 710
10.	Pärt Peterson	51	8 850

## CONCLUSIONS

Ranking of the best 10 Lithuanian, Latvian and Estonian (three Baltic states) researchers from several disciplines using Google Scholar database is presented. The ranking is made based primary on h-index and total citation number based on the database in Google Scholar. Researches ranked first by h-index in decreasing order and then by the total number of citations. Based on the Tables 2, 3 and 4, in accordance with the h-index, the country's ranking is the following: 1. Estonian, 2. Lithuanian, 3. Latvian.

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# FLUID-DEPOSITION OF ROCKS IS NATURAL MODEL FOR ADDITIVE PRODUCTION

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DOI: 10.7906/indecs.15.3.2  
Regular article

Received: 10<sup>th</sup> October 2017.  
Accepted: 17<sup>th</sup> October 2017.

## ABSTRACT

All created in the Nature is the result of natural technology. Solutions from Nature can be incentive for artificial, man's technology of living (biotechnology) and technology of abiogenesis. We have set ourselves the question what is a natural additive model for making parts. After geological analysis and playback of some products of Nature and man-making procedures of additive components was found. Natural model for these procedures to create additive components is the formation of sedimentary rocks 3,75 billion years ago. At the same time we made systematization of additive production and additive manufacturing of these procedures, the first revolutionary change in the primary shaping after 4,3 billion years.

## KEY WORDS

natural rocks, natural model of additive processes, additive production, additive manufacturing

## CLASSIFICATION

JEL: O14

PACS: 91.60.-x

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## **INTRODUCTION**

The first additive production process, stereolithography has been introduced by *3D Systems* in 1986 [1]. Only three decades later, additive production is on the way to be a regular process for production of material products from living and non-living substances [2].

Stereolithography (SLA or STL) is an additive production process (generic deposition primary shaping) which employs a vat of liquid ultraviolet curable photopolymer resin and an ultraviolet laser to build parts' layers one at a time [1].

In our time among other trends, one very strong trend is interconnection between biotechnology and technology (of non-living systems). This demands looking into natural technology solutions, to receive ideas for our human, artificial technology. But one trend is underestimated, synthesiological way of thinking. We have too much information, too much partial research, but without the effort to attempt to put this knowledge into new structured cognitive systems.

We try to introduce into our research a synthesiological approach [3]. While describing the history of natural technology for the past 4,4 billion years, we assume to discover the natural model for all deposition procedures of generic, additive production of prototypes, tools, including moulds and more and more, parts and things. This discovery is based on a description – probably the oldest fluid-deposited rocks on Earth, 3,75 billion years old [4].

How do we connect this description with the additive production of parts? According to the origin, rocks can among others sedimentary (depositional) one. At the same time about 95% of additive production procedures are based on deposition. So, we come to conclusion that natural deposition primary shaping is at least 3,75 billion years old. To support this conclusion, we must make clear difference between the words production and manufacturing.

## **DIFFERENCE BETWEEN WORDS PRODUCTION TECHNOLOGY AND MANUFACTURING TECHNOLOGY**

Production (fabrication) technology is according the systematization given in DIN 8580 [5] and G. Ropohl [6] a common name for processing technology and manufacturing technology<sup>1</sup>. Mostly the procedures of the additive method of making parts are production based. This means that the primary shaping (manufacturing technology) precedes the making of material (processing technology). In clear text, during deposition additive production methods we made first the layers (primary shaping – manufacture technology) which would be than solidified by some chemical reactions like polymerization and/or curing (processing technology). An excellent example for the description of additive production is mentioned SLA procedure [7]. First we must to build up from liquid epoxy resin (substance) a necessary layer (primary shaping – manufacturing) and then followed by a laser-induced polymerization and cross-linking of photo activated resins (processing technology) [7]. Not before the reactions of polymerization and cross-linking are finished, we have no product with necessary application properties [8].

Primary shaping in manufacturing is connected with a given primary shape to produce, but can only occur with a change of the state of materials: solid – liquid – solid. Example of this is process fused deposition modelling – FDM [9-11].

It will be shortly described in the additive production of parts with the aim of visualisation of the difference between additive production and manufacturing technologies, based on the state of the substance.

## ADDITIVE PRODUCTION OF PARTS

The important revolution in the whole history of the production of parts is primary shaping, without using a cavity in a mould, as means of action. The introduction of computers into the production of parts makes it possible.

We start with the hypothesis that the natural model of the most of generative, additive making procedures (methods) is the fluid-deposition making of sedimentary rocks.

From time of making first natural product, inorganic polymer, zircon 4,3 billion years ago, primary shaping and primary structuring was always in some sort of mould. In the case of zircon the mould was the core of Earth [3].

Additive making procedures (methods) allow the production of parts without a cavity (hollow which is difference between impression and core). For the production of parts by additive procedures we need two steps: preparation of the file with the necessary data as output, and then those data as input transformed into a proper means of action, like 3D-printers.

## PREPARATION OF FILES FOR ADDITIVE MANUFACTURING

There are two principle modes to prepare the necessary files. The first one is the result of development and design of new part (CAD model). The second way is starting with a real part which would be transformed into necessary file by using 3D scanning [12].

3D scanning is a modern technology that can analyse a real-world object or environment to collect data on its shape and possibly its appearance. There are a variety of technologies for digitally acquiring the shape of a 3D object. A well-established classification divides them into two types: contact and non-contact 3D scanners.

## PRODUCTION OF PARTS BY LAYER-BY-LAYER PROCESSES

The basic principle of additive manufacturing is adding material layer-by-layer until the part is finished. Therefore, in literature also can be find term additive layered manufacturing - ALM. This principle is for e.g. opposite of the classic cutting procedures which belong to the group of subtractive processes (turning, drilling, milling, etc.) [12].

Although procedures of additive making parts results with very complicated geometrical 3D shapes of finished parts, generally they are 2½D procedures, in which 2D layers are in general deposited one on each other, and thus a third dimension of the part is achieved [13].

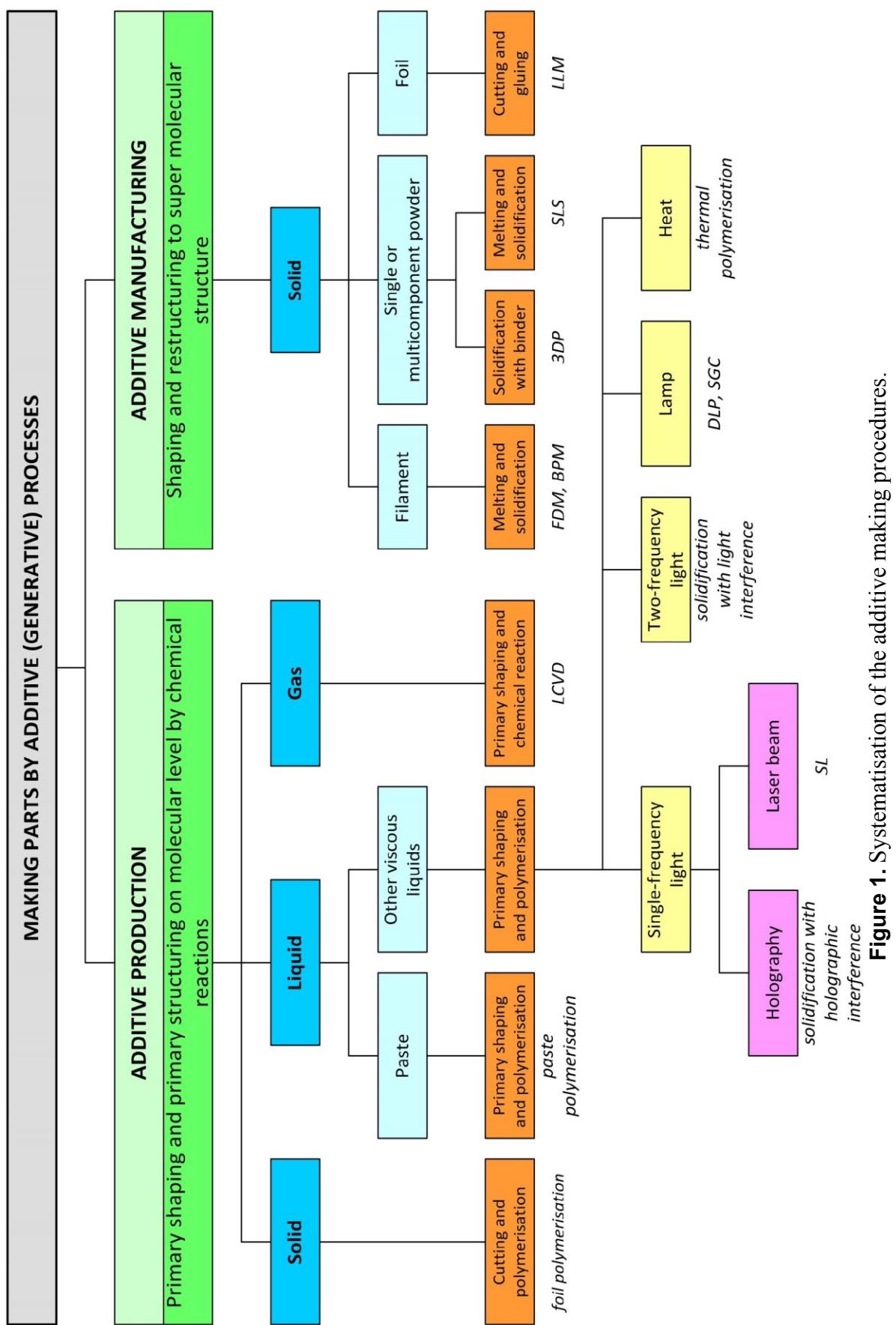
A special characteristic of the additive method of making parts is the fact that the final, physical parts are made directly from the computer 3D data about the part. It is irrelevant what the origin of those 3D data is: CAD design, reverse engineering, computer tomography (CT) or magnetic resonance (MR). From the part's point of view, parts made by procedures of additive making can be considered as a three-dimensional print of the existing CAD data.

Additive making procedures can be divided into a two basic steps: [12]

- generation of mathematical information on layers (virtual environment),
- generation of the layers of physical part (real environment).

The second step is more interesting for this paper, but also for the systematisation of mostly commercial procedures of additive making. In available scientific and professional literature which deals with area of additive making, a lot of many different types of systematisation of those procedures can be found. One of the favourite systematisation of additive making procedures is based on DIN 8580 [5] and DIN 8581 [12] guidelines.

Additive making procedures are classified based type of making (production or manufacturing), state of substances (solid, liquid or gas) – physics and chemistry of the process (Figure 1).



**Figure 1.** Systematisation of the additive making procedures.

Basically it is possible to summarize systematisation as [12]:

- solidification of liquid materials (polymerisation and/or cross-linking process),
- generating a part from a solid state (cutting of foils and plates; application of partly or completely melted solid materials such as powders and powder mixes – processes of extrusion and laser sintering; bonding of powder particle by binder),
- generating a part from pastose state,
- precipitation from gas state.

## **EXAMPLES OF ADDITIVE PRODUCTION AND ADDITIVE MANUFACTURING PROCESSES**

Stereolithography (SLA or SL) is an example of primary shaping and primary structuring on molecular level, where primary shaping is followed by polymerisation and cross-linking, reactive primary shaping, by laser beam.

Reactive primary shaping we found in processing of thermosets (e.g. epoxy resin), rubbers, ceramics and in some cases during primary shaping of thermoplastics is like the casting of poly(methyl methacrylate) (PMMA) [8].

Primary shaping in manufacturing is connected with a given primary shape to the product, but only occurs with a change of the state of materials: solid – liquid – solid. An example of this is Fused deposition modelling – FDM. The solid polymer filament is supplied to the machine through a nozzle, which is computer-controlled and in one layer it forms the raster of the item in the respective layer. The material exits the nozzle in liquefied/softened state and at ambient temperature solidified quickly to solid body. The entire system is usually in a heated environment. After making the first layer, the working bed is lowered for the thickness of the new layer and the new layer is extruded [9-11]. In more complex product geometry, the support structure may be used. In this case a double extrusion head is used. It is possible to extrude PE-HD, PE-LD, PP, ABS and also biocompatible and/or biodegradable materials (e.g. polycaprolacton – PCL) and elastomers and it is possible to simultaneously produce several prototypes. FDM can also produce support structure made from same material as product and with one head only. Support structure in this case and at the end of production is removed mechanically [11, 14, 15].

The described procedures are in principle deposition one. We try to proof our hypothesis. Is possible the natural model of additive making of parts fluid-deposition of rocks? This idea has been proved first by geological analysis.

## **GEOLOGICAL ANALYSIS**

During this analysis we study two examples of sedimentary rocks [16, 17].

Starting from the assumption that the sedimentary rocks are a natural model for making a product by additive processes, there been found two examples, gypsum and pelite sedimentary rocks.

Figure 2a shows a hand sample of gypsum, very common evaporate sedimentary rocks. The sample is from the site of Mali Kukor from Southern Croatia, where gypsum was deposited at the end of the Paleozoic Era in the Upper Permian meaning 250-260 million years ago [16].

Figure 2a clearly expressed horizontal lamination (thickness thinner than 1 cm) and is an indicator of seasonal changes in the conditions of deposition. Lighter laminae are composed of gypsum (inorganic polymer), while darker laminae with plaster containing higher amounts of organic matter. Precisely it is the inorganic-organic composite creation.



**Figure 2.** a) the sample of horizontally laminated gypsum from the site of Mali Kukor (age 250-260 million years) [16], b) the hand sample of horizontally laminated pelite sedimentary rock from the site Voćin 12 million year old [17].

Figure 2b shows hand sample of pelite sedimentary rock from Voćin locality, Eastern Croatia, composed of alternate laminae of silt and marl. The rock is an inorganic polymer with a well-defined horizontal lamination deposited in the Middle Miocene Epoch, about 12 million years ago [17].

An important property of sedimentary rock is the arrangement in the layers, in our case, the most interesting is the horizontal layering (lamination). Which indicates that the initial assumption that the natural model for additive production, formation of sedimentary rocks is acceptable.

We decided to proof our hypotheses using CD scanning equipment, 3D printers and used geological materials.

## EXPERIMENTAL PROOF

Using three different types of printers and different materials for printing we produce parts which demonstrate the origin of additive production and we made a comparison with historical materials found in the nature.

## MATERIALS AND EQUIPMENT

We used for scanning following cameras: ATOS II (procedure A), AVT Guppy F080B FireWire 400 camera (procedure B) and ATOS Core 135 (procedure C).

In Table 1 is given some technical specifications of 3D printing devices for all cases (A, B and C) which is shown in Figure 3a - f.

## PROCEDURE A

The rock specimen originating from Ilijadža, Bosnia and Herzegovina and exported scan made with non-contact 3D scanner ATOS II is given in Figure 3a and 3d [17, 18].

The scan presents the rock called aragonite. Prismatic crystals of mineral aragonite ( $\text{CaCO}_3$ , polymorphic modification) originated from hydrothermal solution at low temperatures ( $60^\circ\text{C}$ ).

Aragonite is a very unstable mineral and is easily converted into more stable calcite ( $\text{CaCO}_3$ ). Brown – yellow colour of aragonite comes from the presence of Fe oxide and hydroxide – (limonite).

Because of the bright colour of the rock, it is difficult to notice the layered texture of the real material. After the polygonization, created CAD model can be exported into the some software for next analyses or printing.

For producing the replicas in the procedure A the material used has been a kind of composite material based on blaster compounded with binder. After each layer, the substances must react with the binder. After this description of used materials and the necessity of reaction, give us right to call this procedure the production one.

The replicas has been successfully made, however, due to the type of available material, the printed layers are not clearly visible, so the replica missed here [18].

**Table 1.** Technical specifications of 3D printing device.

Technical specification	Procedure A	Procedure B	Procedure C
Procedure used	Z 510	<i>Zprinter 450</i>	<i>PolyJet</i>
Reactive procedure, yes-no	yes	yes	yes
Build speed, layers/min	2	2	
Layer thickness, mm	0,089-0,203	0,089-0,102	0,016
Resolution, dpi	600 × 540	300 × 450	600 × 600 × 1600
Material options	High-performance Composites, Casting Materials, Elastomeric Material	High-performance Composites	Photopolymers
Material used	Composite material (USA)	Composite material (USA)	VeroWhite (Izrael)
System software	ZPrint	Z Corporation's proprietary software accepts solid models in STL, VRML PLY, and 3DS file formats as input. ZPrint™ software features 3D viewing, text labelling, and scaling functionality	Objet Studio for Connex 350
Input formats	STL, VRML, PLY and 3DS	STL, VRML, PLY, ZPR and 3DS	STL, OBJDF, SLC
Printer	Z 510	<i>Zprinter 450</i>	<i>Connex 350</i>
Printing system	inkjet layer printing system	inkjet printing system	UV hardening

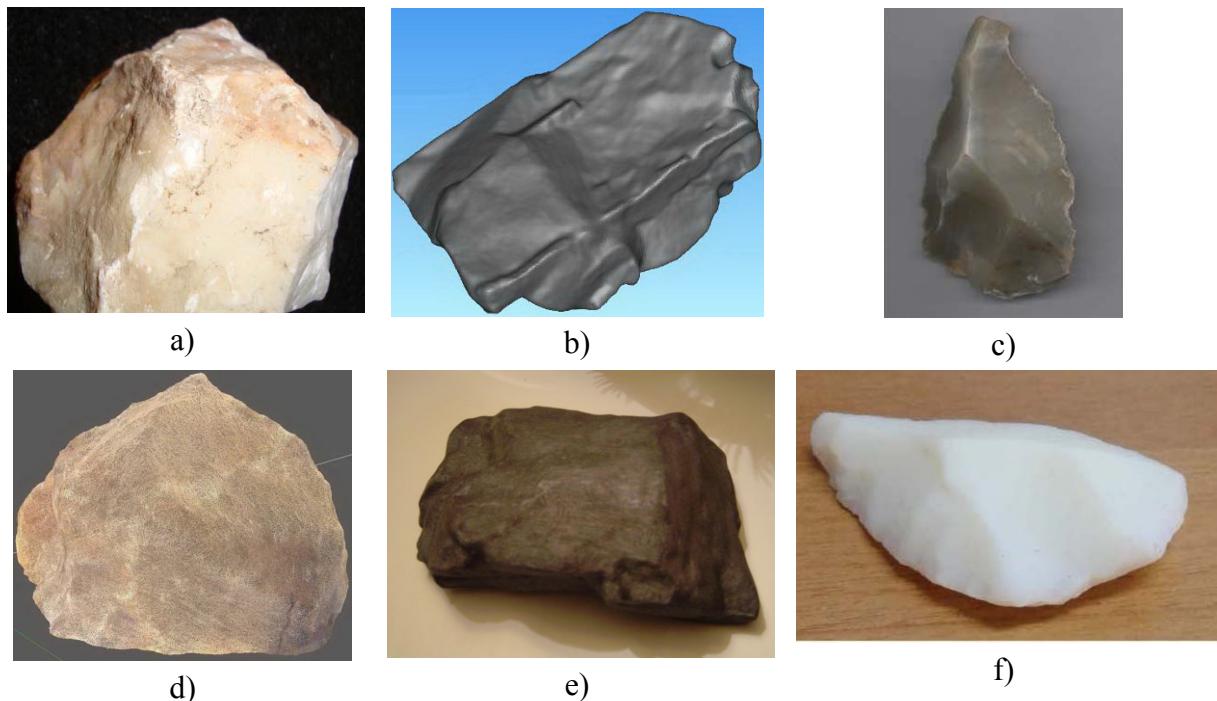
## PROCEDURE B

For second test procedure we found specimen from a place in the pedestal of a mountain in Vlašić, Bosnia and Herzegovina (Figure 3b). This rock has been collected for making stone tools during an education process at the University of Zagreb, Department Archaeology. The material of the stone is chert, sedimentary rock originating from radiolarite of Triassic or Jurassic time.

The basic material for printing was composite material (USA), a fine powder based on calcium carbonate ( $\text{CaCO}_3$ ) with organic additives in solid state. The powder is bonded during printing process with a binder (adhesive) (USA) from the inkjet print head. ZPrinter 450 uses Drop-on-demand inkjet printing method.

ZPrinter 450 creates 3D models by binding composite material using heat-activated printing additive and adhesive material. This method is frequently referred as reactive printing procedure (Figure 3e).

For the 3D scanning purpose Mephisto Basic 3D scanning system was used. Final version of the scanned model was created with MeshLab open source software and exported to WRML format [19, 20].



**Figure 3.** a) specimen of rock aragonite, originating from Ilidža, b) rock's specimen from Vlašić scanned by *AVT Guppy F080B FireWire 400* camera, c) specimen of original stone shave from Mujina cave scanned by *ATOS Core 135*, d) 3D model of scanning Ilidža's rock by *ATOS II*, e) printed specimen from Vlašić with *Zprinter 450*, f) stone shave from Mujina cave printed by *PolyJet* printer.

### PROCEDURE C

Figure 3c represents possibility of additive technologies in archaeology. This is stone shave from Mujina pećina (cave), site near Split, South Croatia and is 41,000 year old. Stone shave was made by Neanderthals from stone chert.

Chert is microcrystalline or cryptocrystalline sedimentary rock material composed of silicon dioxide ( $\text{SiO}_2$ ). It occurs as nodules, concretionary masses and as layered deposits. Chert breaks with a conchoidal fracture, often producing very sharp edges [21] therefore Neanderthals used it for cutting tools.

For the possibility of getting sharp edges and surface with small roughness PolyJet process was used. ATOS Core 135 was used for scanning and for additive manufacturing Connex 350. Material was white acrylic photopolymer.

Figure 3c shows the original stone, and 3e printed. In the Figure we can observe sharp edges and smooth surface. On the printed product it can't be seen layers because Polyjet process produces layers of 16 µm thickness.

## CONCLUSION

The specimen's researchers found of rock gypsum and pelite encouraged researchers to scan mode two mineral from other substances. Scanning and procedures described in additive production have been proven to be a natural model of additive production that began before 3,75 billion years ago. It should be noted that the development of additive production without moulds, back in 1986 is the first revolutionary change in the primary shaping of parts, since the making of zircon formation period, 4,3 to 4,4 billion years ago.

## ACKNOWLEDGEMENT

We give a credit to all persons who support us in this project. Particularly to Prof Ivor Karavanić from University of Zagreb, Faculty of Humanities and Social Sciences. This work has been induced by first author who is retired scientist, mostly occupied by synthesiological research. Other authors help him within other different projects, only few mentioned.

The contribution to this paper is based on project Application of theory of systems in analysis of general technology, supported by the Ministry of Science, Education and Sports of the Republic of Croatia.

This work is also part of the research financed by the project IPA III c – Additive Technologies for the SMEs – AdTecSME, supported by the European Union and the Ministry of Science, Education and Sports of the Republic of Croatia.

The authors would like to thank all those help in financing our projects, from which part is included in this article.

## REMARK

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# A COMPUTATIONAL TECHNIQUE TO ESTIMATE WITHIN-HOST PRODUCTIVELY INFECTED CELL LIFETIMES IN EMERGING VIRAL INFECTIONS

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DOI: 10.7906/15.3.3  
Regular article

Received: 17<sup>th</sup> July 2017.  
Accepted: 18<sup>th</sup> September 2017.

## ABSTRACT

Emerging viruses cause a lot of fatalities as they jump to humans from other species. Here we develop a novel technique to computationally estimate an important parameter of within-host viral infection: the lifespan of infected cells. Our approach is general and can be applied to a large class of viruses and leverages experimental data from replicon studies. Current techniques have difficulties reliably estimating infected cell lifetimes due to parameter identifiability and correlation of parameters. The infected cell lifetime is an important parameter that gives an estimate of how fast virus levels will decline. Our method would also help determine if some infected cells are short-lived or have longer lifespans with the consequence that longer lived cells could be reservoirs of infection. This would give a mechanistic understanding of why particular cell types are reservoirs of infection and may motivate therapy targeted towards these cell types. We apply our technique to West Nile virus (WNV), an emerging disease of public health relevance related to Zika virus. Our analysis suggests that the most abundant infectible cells are short-lived and could motivate therapy that targets these particular cells. Our approach is very general and can be combined with more traditional methods of using differential equation models to simulate viremia in hosts: the combination of these two techniques will likely yield results that may not be achievable using the models in isolation. This will be of great interest especially in modelling emerging diseases.

## KEY WORDS

viral infections, West Nile virus, replicon studies

## CLASSIFICATION

JEL: I19, Z19

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## INTRODUCTION

Emerging viruses cause a lot of fatalities as they jump to humans from other species. Accurate estimates characterizing the dynamics of the effects of the virus within hosts would give insights into the disease. Here we develop a novel technique to computationally estimate an important parameter of within-host viral infection: the lifespan of infected cells. This is difficult to directly estimate based on only in-vivo (within animals) experiments. Our approach is general and can be applied to a large class of viruses and leverages experimental data from replicon studies. Mathematical models have provided important insights into within-host viral dynamics. For example, human immunodeficiency virus (HIV) infection was modeled to analyze dynamics of the virus in patients which led to estimates of the in-vivo rate of HIV replication and the average life span of productively infected cells [1-4]. These models gave insights into how the virus remained quiescent for years before leading to detectable symptoms. Our primary goal is to outline a novel computational technique to characterize in-vivo productively infected cell lifetimes. Our computational technique leverages advances in genetically modified viruses called replicons. Our approach can complement existing techniques using differential equations and help overcome issues of parameter identifiability and correlation of parameters [5]. The infected cell lifetime is an important parameter that gives an estimate of the how fast virus levels will decline following treatment with antivirals [4]. Accurate estimates of infected cell lifetimes would also be able to suggest if certain long lived cells could be reservoirs of infection. We motivate our analysis by applying our technique to an emerging disease: West Nile virus (WNV), which infects multiple species including humans and has caused high fatalities [6-8]. It is an arbovirus and is in the same family as other viruses such as Zika and hepatitis C virus which are of significant public health concern. Our analysis suggests that the most abundant infectible cells are short-lived (most likely dendritic cells and macrophages) and could motivate therapy that targets these particular cells. We suggest that our approach is very general and can be combined with more traditional methods of using differential equation models to estimate viral parameters within hosts [5]: the combination of these two techniques will likely yield results that may not be achievable using the models in isolation. This will be of great interest in modelling emerging diseases of public health significance.

## MATERIALS AND METHODS

### STUDY DATA

We use data on in-vivo infection of B6 mice with WNV replicons [9]. The WNV replicon was genetically engineered to encode a Renilla luciferase reporter and had the genes encoding for WNV structural proteins deleted. Viral structural proteins were packaged in trans to create virus-like particles as described in [10]. The WNV replicon was injected subcutaneously into the footpad of six week old B6 mice. At various time points, the draining popliteal lymph node was harvested, homogenized and assayed for luciferase activity.

## RESULTS

### ANALYSIS OF DATA ON IN-VIVO INFECTION USING A WNV REPLICON

We analyzed data on in-vivo infection of B6 mice with WNV replicons [9]. Replicons are synthetically modified viruses and in this experiment they were modified:

- 1) to express a gene for bioluminescence so that virus activity could be monitored, and
- 2) structural genes were deleted so that the replicons could not get outside the cell.

Translation of the gene for bioluminescence produces luciferase within the infected cell which converts a substrate to photons. The activity or expression of the luciferase reporter was monitored regularly. This study has several features which help us get constraints on productively infected cell lifespans:

- 1) The WNV replicon kills cells in-vitro and also presumably in-vivo (personal communication Dr. Kristen Bernard, University of Wisconsin-Madison). We note however that insertion of the gene for Renilla luciferase into the WNV genome could negatively impact replication efficiency.
- 2) WNV replicon leads to only a single round of infection in cells.
- 3) The luciferase reporter is not secreted. Hence we only have to consider intracellular decay of luciferase and not clearance of luciferase outside cells (by the action of blood, extra-cellular degradation, etc).

We note the caveat that since the viral structural genes are deleted, there is no viral budding from infected cells and hence cytopathicity can be lower than due to the full length virus. The cells in the draining popliteal lymph node are likely dendritic cells and macrophages (personal communication, Dr. Kristen Bernard). The decline in luciferase reporter expression late in the infection is due to:

- a) killing of cells in-vivo by WNV replicon leading to a decline in luciferase expression,
- b) decay of luciferase within the cell,
- c) migration of replicon infected dendritic cells and macrophages out of the draining lymph node and
- d) inhibition of replicon replication by cellular interferon.

One study observed a small dendritic cell population in thoracic duct lymph that had presumably migrated from the lymph node and measured it to be a very small percentage (approximately 0,013 %) of all viable cells [11]. It is also not completely understood whether and how dendritic cells exit the lymph node [12]. Hence in what follows, we ignore migration of infected dendritic cells and macrophages from the draining lymph node. We represent the dynamics of luciferase activity in the declining phase by the following model:

$$\frac{dI_2}{dt} = -\delta I_2, \quad (1)$$

$$\frac{dL}{dt} = \kappa I_2 - \mu L. \quad (2)$$

Cells that are infected with the replicon and actively producing luciferase intracellularly are represented by  $I_2$ . Productively infected cells ( $I_2$ ) die at a rate  $\delta$  per cell because of the WNV replicon, where  $1/\delta$  is the average life span of a productively infected cell. The kinetics of intracellular luciferase ( $L$ ) is dictated by luciferase expression within productively infected cells ( $I_2$ ) mediated by a constant  $\kappa$  and intracellular decay at rate  $\mu$ . Solving the equations above, assuming initial conditions  $L(0) = 0$ , leads to the following equation for the kinetics of luciferase expression within productively infected cells:

$$L(t) = \alpha(e^{-\delta t} - e^{-\mu t}). \quad (3)$$

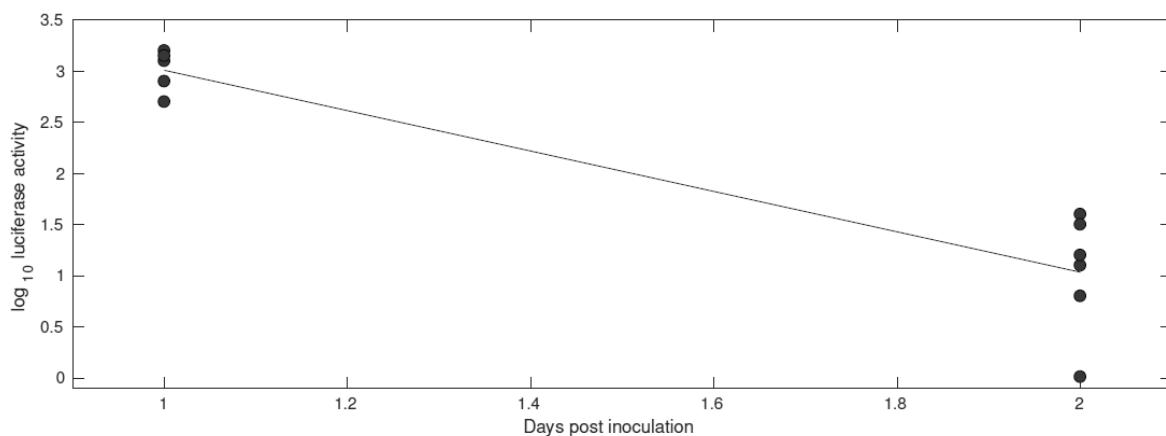
where  $\alpha$  is a constant. Luciferase decays rapidly within cells with a half-life of approximately 2 hours [13] yielding a decay rate ( $\mu$ ) of 8,3 / day. Because of this rapid decay, we can approximate the dynamics of intracellular luciferase after an initial transient phase by the following equation:

$$L(t) \approx \alpha e^{-\delta t}. \quad (4)$$

We fit Equation 4 to data in [9] (Figure 1) for the decaying phase of luciferase and estimate  $\delta$  to be approximately 5,2 / day, giving us a mean productively infected lifespan ( $1/\delta$ ) of approximately 5 hours ( $r^2 = 0,85$ , ordinary least squares slope = -1,98).

We also developed the complete model (without approximating that luciferase decays rapidly) and explicitly simulate the decay of luciferase. We show the results of the simulation in Figure 2. We note that it does not change the results (produces the same estimate of cell lifetimes). It predicts an initial increase in observed luciferase due to the translation of replicons to luciferase. This can be verified experimentally if it is feasible to take measurements within a few hours of inoculation by replicons.

In summary, our analysis of data from an in-vivo WNV replicon study suggests that cells in the draining lymph node, likely comprising dendritic cells and macrophages, have a productively infected cell lifespan of approximately 5 hours in mice.



**Figure 1.** Equation 4 fit to data on luciferase activity in mice using a WNV replicon (data from [9]) ( $r^2 = 0,85$ , ordinary least squares slope = -1,98).

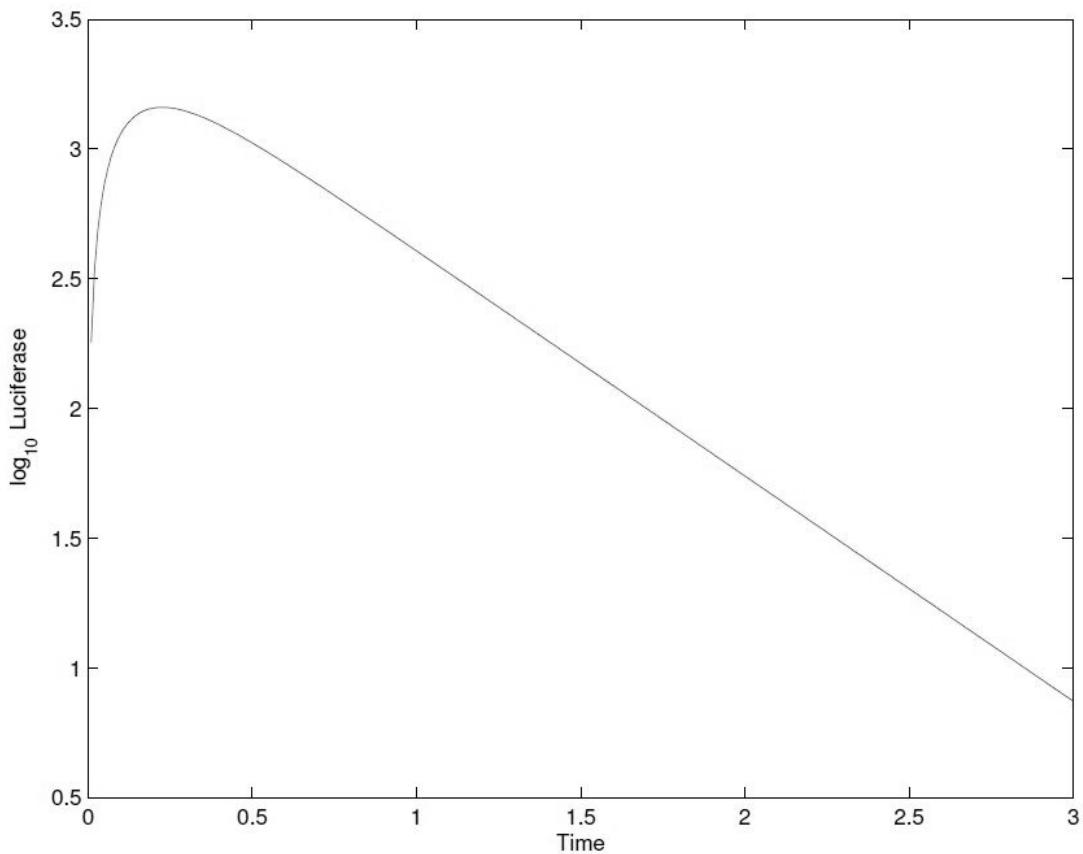
## DISCUSSION AND CONCLUSION

We describe a method to computationally estimate infected cell productively infected lifetimes based on experimental data for an emerging disease: West Nile virus (WNV). WNV is a flavivirus and is in the same family as other emerging diseases of public health concern such as Zika virus and hepatitis C virus. Our technique leverages data from a replicon system (synthetically modified virus) that encodes a gene for fluorescence which enables direct visualization of virus activity. We use a dynamical systems model to estimate an important biologically relevant parameter: the lifespan of infected cells that are producing virus. Having outlined our computational technique to infer infected cell lifetimes from a novel experimental dataset, we suggest how it can complement existing analysis of viral studies. We focus on West Nile virus (WNV) as a candidate system but a similar analysis can also be done for other viruses for which replicons can be engineered.

WNV infects multiple cell types: some are short-lived and some have longer lifespans with the consequence that longer lived cells could be reservoirs of infection. Our analysis of in-vivo infection data using WNV replicons (Figure 1) suggests that cells in the draining lymph node, likely comprising dendritic cells and macrophages, have a productively infected lifespan of approximately 5 hours.

A previous mathematical model trained on infection data in mice (using a non-linear differential equation model of viral kinetics) predicts a productively infected cell lifetime of 2 to 14 hours in-vivo. Our current analysis also supports this, suggesting that in-vivo lifetimes of infected cells (comprised of macrophages and dendritic cells) is approximately 5 hours.

However, another study suggests that other cell types (keratinocytes) have longer productively infected lifespans in-vitro than our estimates in-vivo from mice [5].



**Figure 2.** Simulation of complete system (Equation 3) over time (days) (explicitly modelling luciferase decay).

Is it possible to reconcile all these studies? We suggest the possibility that cells with short productively infected cell lifespans (like dendritic cells and macrophages) contribute significantly more to viremia in serum in mice than keratinocytes with longer productively infected cell lifespans. That would explain the relatively short infected cell lifetime (2 to 14 hours) in previous models [5] since the short-lived cells (dendritic cells and macrophages) are possibly more abundant. There are likely more susceptible dendritic cells and macrophages in the lymph node, spleen and kidney than there are keratinocytes in skin. We can reason about this as a two compartment system: one compartment is long-lived but less abundant (comprised of keratinocytes) and another compartment is short-lived but abundant (comprised of macrophages and dendritic cells). Hence the short-lived cells could contribute more to viremia and estimates of lifetimes would be closer to the lifetimes of these cells (2 to 14 hours).

This is akin to the situation in HIV, where infected CD4+ T-cells are short-lived and contribute significantly more to peripheral viral load than longer lived cell populations, such as macrophages [4]. Taken together with previous experimental results, our modeling suggests that cells with relatively short productively infected lifespans (likely dendritic cells and macrophages) in lymph node, spleen and kidney likely contribute significantly towards WNV viremia in serum during the acute phase of infection.

This would also be consistent with studies that inhibited replication in dendritic cells and macrophages and observed reduction of WNV titer in serum to undetectable levels [14] (also personal communication Dr. Manjunath Swamy, Texas Tech University). We note however,

that keratinocytes also play a very important role in WNV pathogenesis. Long lived infected keratinocytes contribute towards persistent viremia in skin and peripheral organs months after infection, even well after viremia has declined to undetectable levels in serum [15]. Keratinocytes are also the initial targets of WNV infection [9] and promote migration of infected Langerhans cells to the draining lymph node [16], which in turn facilitates systemic spread of WNV [16].

In summary, our analysis suggests that the most abundant infectible cells in WNV are short-lived. These cells are most likely dendritic cells and macrophages and could be reservoirs of infection. This could motivate therapy that specifically targets these cells. Therapy during the acute phase of infection could be targeted towards short-lived cells (dendritic cells and macrophages) whereas therapy during the chronic phase can be directed towards keratinocytes. Our computational technique yields biological insights that complement approaches using differential equation models to fit viremia data [5]. This suggests a novel way to combine traditional differential equation models with models fit to replicon data and could be applied to other emerging diseases, e.g. Dengue virus for which replicons have also been constructed [17].

Finally, we note that we analyzed data from in-vivo infection of mice with WNV replicon particles modified to be capable of only one round of infection and encoding an intracellular luciferase reporter. The fact that these particles are capable of only round of infection and that they decay very rapidly in the intra-cellular environment is critical since it considerably reduces the parameters that need to be estimated.

Our modeling makes suggestions for further experimental work. More frequent measurement of replicon and simultaneous measurements with viremia in serum (both in-vivo and in the same strain of mice) may help in getting more accurate estimates of biologically relevant model parameters.

Our method is general and can be applied to other emerging viral infections where replicon experiments are feasible, e.g. in Dengue virus [17]. Our technique can complement current approaches using ordinary differential equations and can help overcome problems of parameter identifiability and correlation of parameters (like the lifetime of infected cells) [5]. The infected cell lifetime is an important parameter that gives an estimate of the how fast virus levels will decline following treatment with antivirals [4].

Accurate estimates of infected cell lifetimes can also suggest if some cell types are long-term reservoirs of infection as we have shown in the preceding analysis with WNV. This would give a mechanistic understanding of why particular cell types are reservoirs of infection and give insights into why some viruses seem to be specialized for certain cell types (cell tropism).

Accurate estimates of infected cell lifetimes can also be compared to the theoretically predicted value for optimal propagation [18] giving insights into how far a given strain of virus is from mutating into a more virulent strain. Such an analysis can also be incorporated in scaling parameters of disease progression between hosts [19]. This would enable us to couple within host models of viral kinetics to models of how viruses spread between hosts, enabling modelling of diseases at multiple scales. Our work also suggests a generality and power of dynamical models in capturing rich features of diverse complex systems ranging from immune systems and intra-cellular regulatory networks to global scientific collaboration networks [20-34].

In summary we suggest that our approach is very general and can be combined with more traditional methods of using differential equation models to estimate parameters of viremia in hosts [5]: the combination of these two techniques will likely yield results that may not be achievable using these models in isolation. This will be of great interest especially in modelling emerging diseases and viral infections of public health significance.

## ACKNOWLEDGEMENTS

Author thanks to Dr. Alan Perelson, Dr. Kristen Bernard and Dr. Manjunath Swamy for helpful discussions.

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# AUTOMATED INTERPRETABLE COMPUTATIONAL BIOLOGY IN THE CLINIC: A FRAMEWORK TO PREDICT DISEASE SEVERITY AND STRATIFY PATIENTS FROM CLINICAL DATA

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DOI: 10.7906/15.3.4  
Regular article

Received: 7<sup>th</sup> September 2017.  
Accepted: 6<sup>th</sup> October 2017.

## ABSTRACT

We outline an automated computational and machine learning framework that predicts disease severity and stratifies patients. We apply our framework to available clinical data. Our algorithm automatically generates insights and predicts disease severity with minimal operator intervention. The computational framework presented here can be used to stratify patients, predict disease severity and propose novel biomarkers for disease. Insights from machine learning algorithms coupled with clinical data may help guide therapy, personalize treatment and help clinicians understand the change in disease over time. Computational techniques like these can be used in translational medicine in close collaboration with clinicians and healthcare providers. Our models are also interpretable, allowing clinicians with minimal machine learning experience to engage in model building. This work is a step towards automated machine learning in the clinic.

## KEY WORDS

disease severity prediction, machine learning, computational technique, big data

## CLASSIFICATION

JEL: I19, C63

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## INTRODUCTION

The advent of big data and clinical records databases opens possibilities for clinical data science. Machine learning techniques coupled with clinical data is thought to be critical in delivering the next generation of healthcare [1].

Here we present an automated computational framework to derive insights from clinical data. The computational framework presented here can be used to stratify patients, predict disease severity and propose novel biomarkers for disease. Our approach automatically performs model inference, cross-validation, model selection and generates insights with minimal operator intervention. Our models are also interpretable, allowing domain experts like clinicians (with minimal machine learning experience) to engage in model building. Insights from machine learning algorithms coupled with clinical data may help guide therapy, personalize treatment and help clinicians understand the change in disease over time. Our approach is a step towards automated machine learning and computational biology in the clinic.

## METHODS

We have developed an automated machine learning framework that performs predictions with minimal operator intervention. First, we perform feature scaling to ensure that all input features are on the same scale. We then look at a suite of different machine learning techniques like neural networks, random forests, regularized generalized linear model (logistic regression) with LASSO (least absolute shrinkage and selection operator), support vector machines, linear regression and principal components analysis. Crucially, we perform inference, cross-validation, model selection and insight generation with minimal operator intervention.

## DATA

We used data from the UCI machine learning repository (Wisconsin breast cancer dataset, which are available for download from [2]), [3, 4]. The dataset consists of 699 patients divided into healthy and patients with breast cancer. The disease status is reported as benign or malignant. The different attributes measured were clump thickness, uniformity of cell size, uniformity of cell shape, marginal adhesion, single epithelial cell size, bare nuclei, bland chromatin, normal nucleoli and mitoses. All predictors are numeric (there are no categorical predictors) and were scaled to be within a range of 0 to 10. We replaced missing values with a 0. Future work will look at schemes to impute these values. Finally, we split the data into training, cross-validation and test sets.

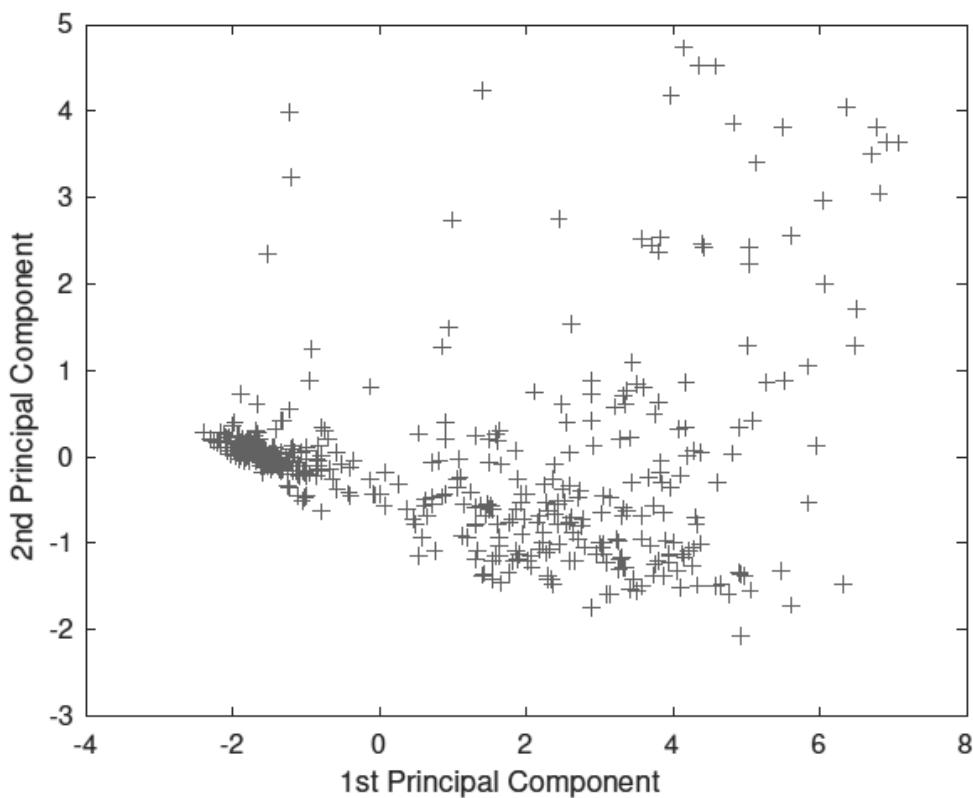
## RESULTS

### STRATIFYING PATIENTS

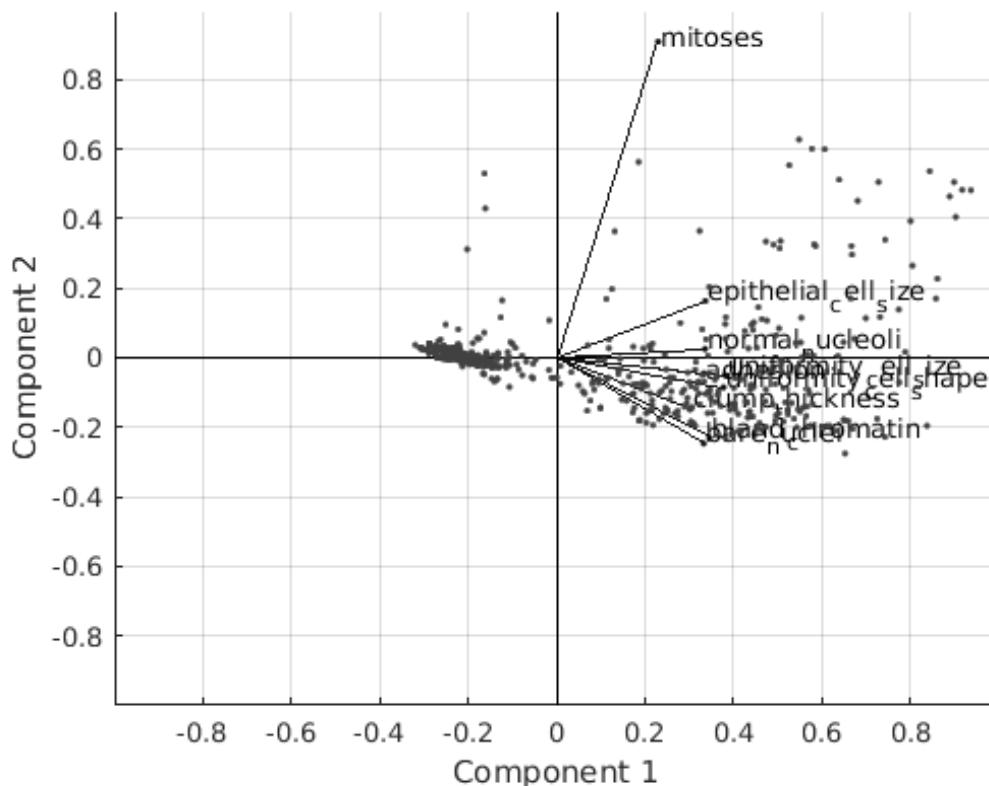
We used principal component analysis (PCA) to gain insights into the clinical data. The PCA analysis suggests that there are a few clusters that the data can be separated into (Figure 1 and Figure 2). Single epithelial cell size and uniformity of cell shape seem to separate the data into distinct clusters (Figure 2). The attribute mitoses seem to account for many outliers (Figure 2).

We note that the first principal component explains about 65 % variance in the data (Figure 3).

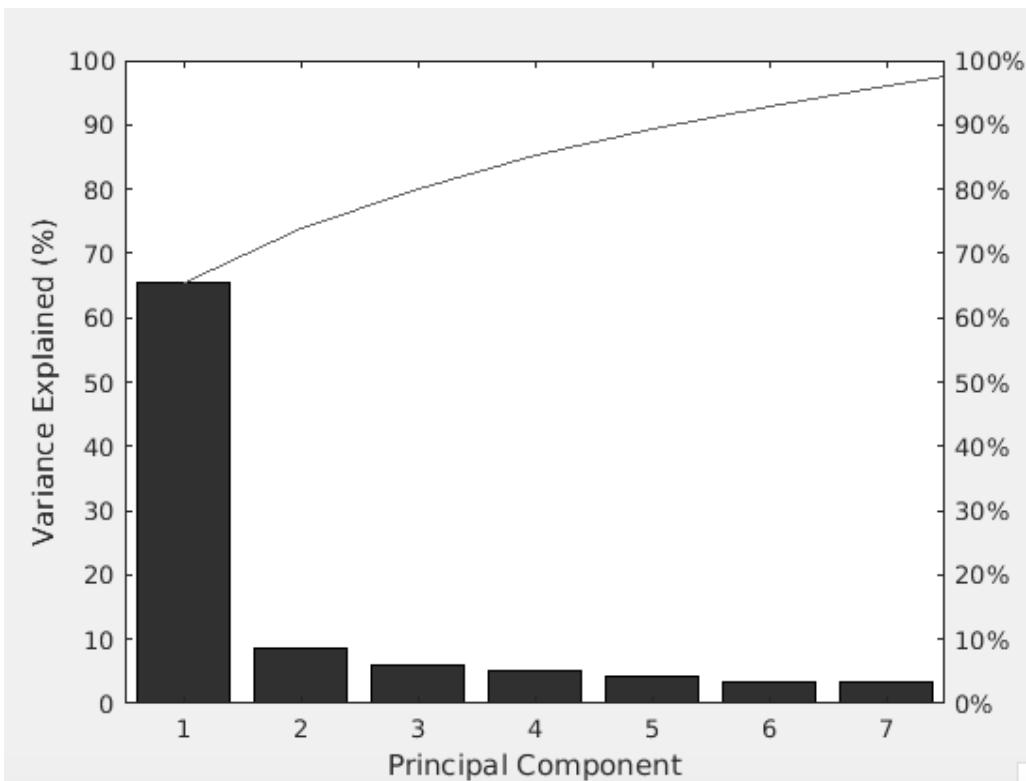
Finally, the PCA analysis suggests the most extreme points in the data (outliers). Five patients with codes 1123061, 1198128, 1147748, 1165926 and 760001 are predicted to be outliers. For example, patients coded as 1123061 and 760001 have a very low value ( $< 3$ ) for the uniformity of cell shape. Patient coded as 760001 has a very low value of mitoses (value of 1 on a scale of 1 to 10). All patients predicted to be outliers also have low values of the attribute bare nuclei. This kind of analysis can be used to stratify patients.



**Figure 1.** Principal components analysis of data. Analysis shows a few clusters for the first two principal components.



**Figure 2.** Principal components analysis of the data showing clusters for the first two principal components.

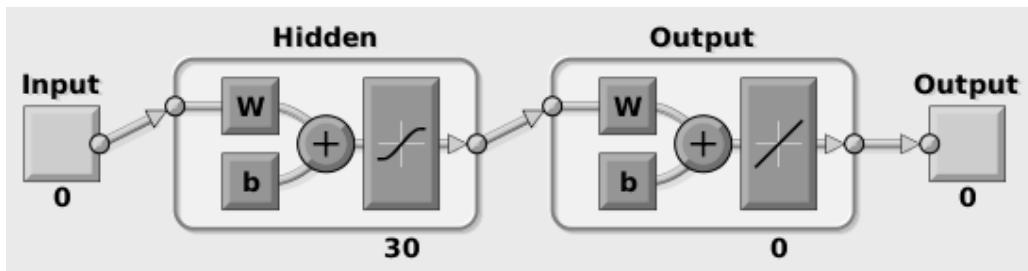


**Figure 3.** Percentage of variation explained by each principal component in a PCA.

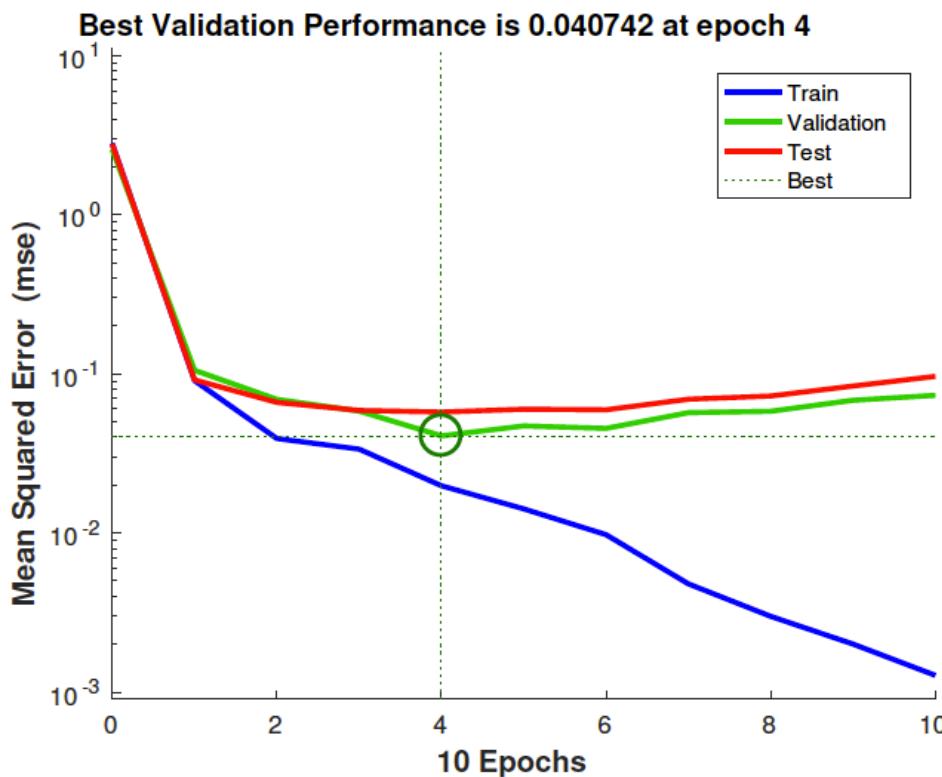
## PREDICTING DISEASE SEVERITY

We predict disease severity or probability of getting the disease using a suite of different machine learning algorithms. We looked at artificial neural networks (Figure 4) which are composed of an input layer of features, hidden layers and an output layer that predicts disease severity (on a scale of 0 to 1). We varied the number of hidden layers from 1 to 100. A neural network with 10 hidden layers was found to give the best performance (mean squared error equal to 0,01) as shown in Figure 5 and Figure 6.

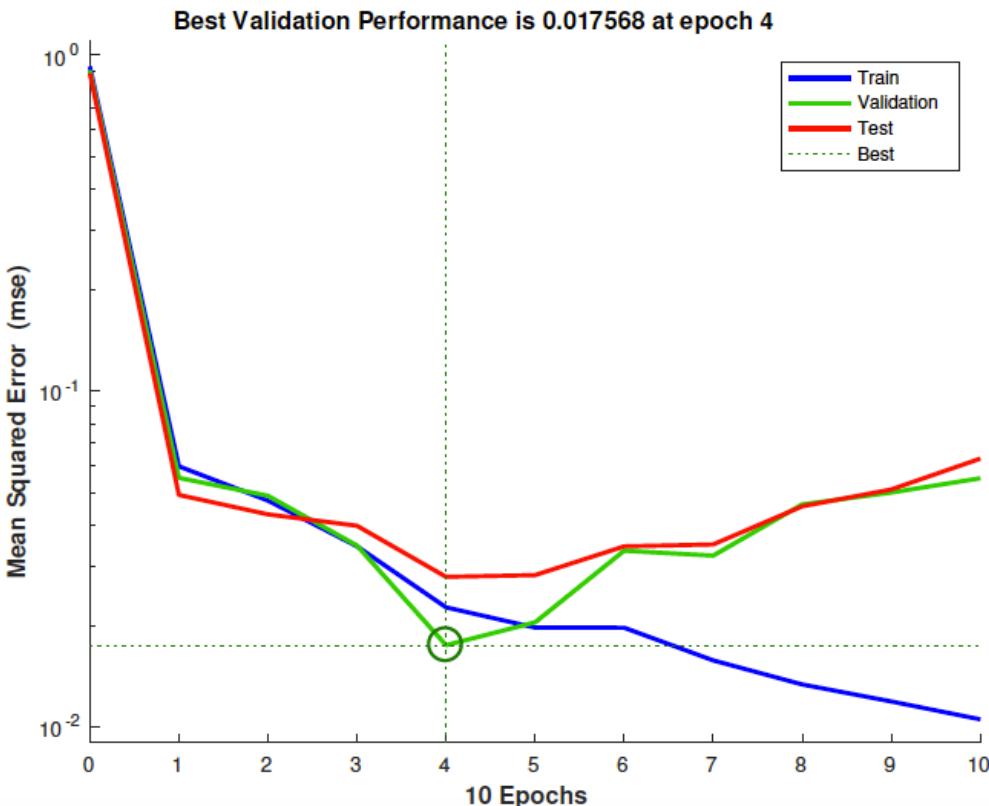
We also used random forests which are collections of trees. Each tree can be interpreted as a set of rules that suggest how to combine the attributes to predict a disease severity. A forest is a collection or ensemble of such trees. We varied the leaf size from 5 to 100 and the number of trees that are grown from 1 to 50 (Figure 7). The best random forest model achieved a cross-validation mean squared error of 0,04.



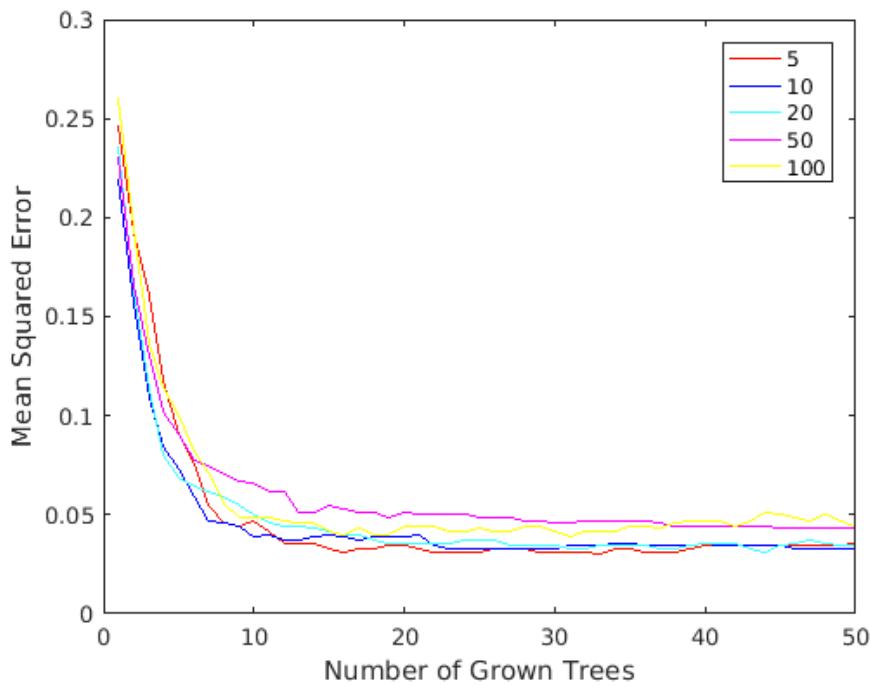
**Figure 4.** Architecture of neural network used to predict disease severity. The network shown has an input layer, 30 hidden layers and an output layer.



**Figure 5.** Neural network performance on training, validation and test dataset with 30 hidden layers.



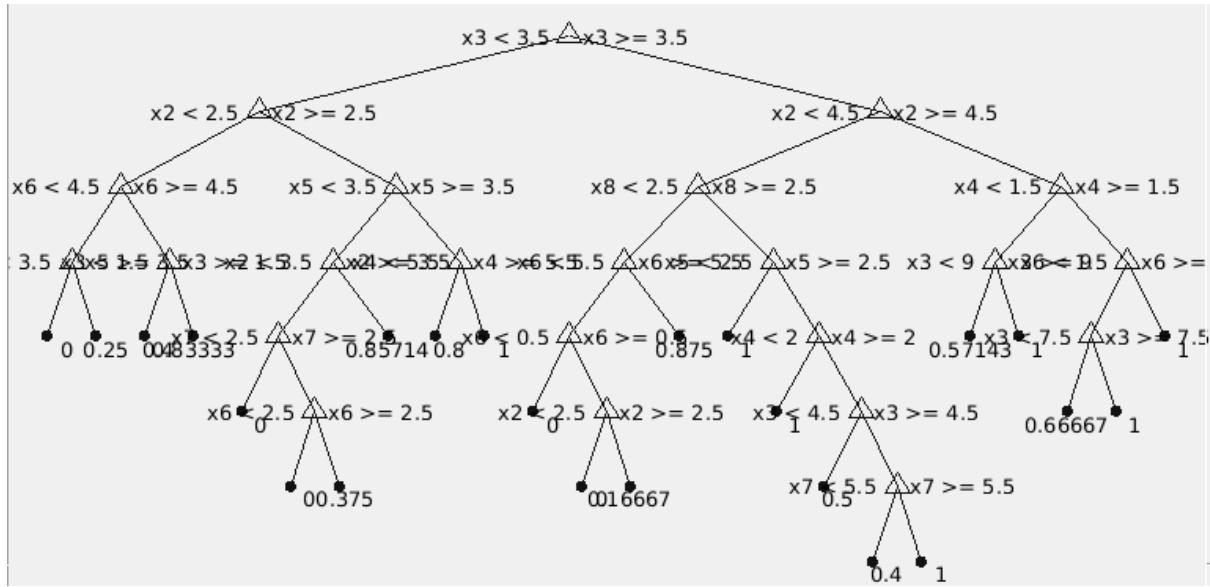
**Figure 6.** Neural network performance on training, validation and test dataset with 10 hidden layers.



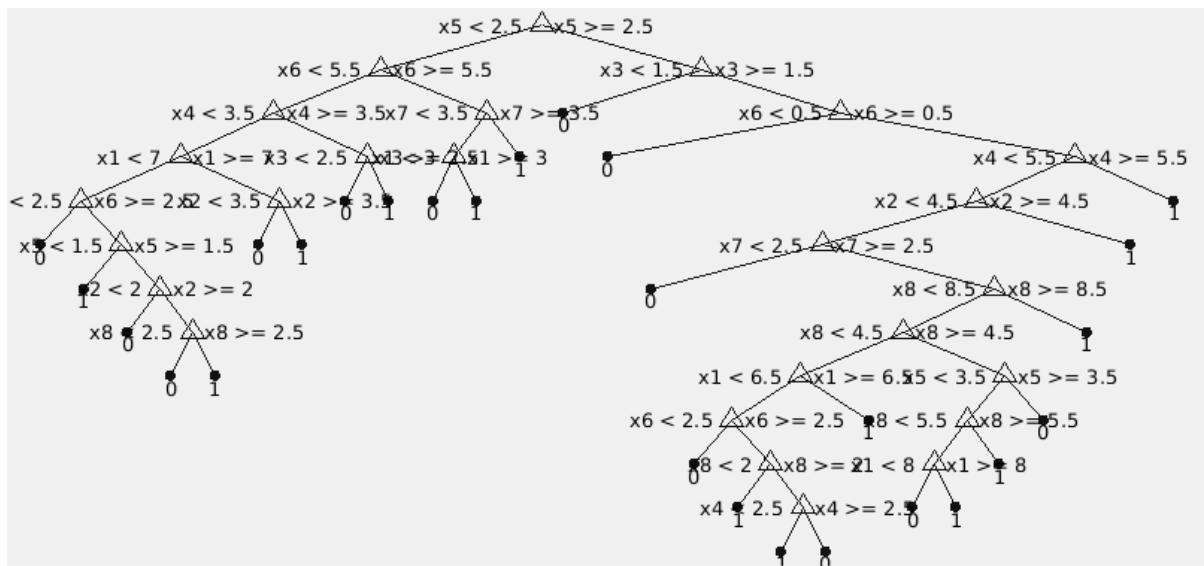
**Figure 7.** Performance of a random forest algorithm (out of bag prediction error). The leaf sizes are varied from 5 to 100 and up to 50 trees are grown.

Representative trees used for predicting disease severity are shown in Figure 8 (regression) and Figure 9 (classification). Random forests are very interpretable. For example, the tree shown in Figure 9 is very interpretable since it represents a rule of the form:

IF [*(single epithelial cell size  $\geq 2.5$ ) AND (uniformity of cell shape  $< 1.5$ )*] THEN *healthy* (1)



**Figure 8.** A representative tree from the random forest used in predicting disease severity (regression).

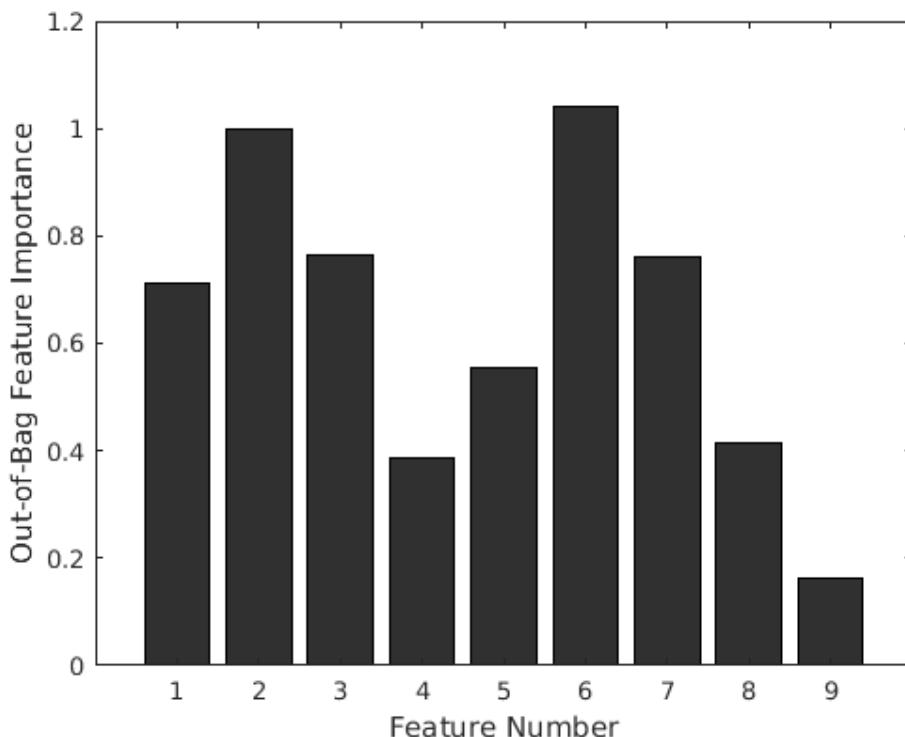


**Figure 9.** A representative tree from the random forest used in predicting disease severity (classification).

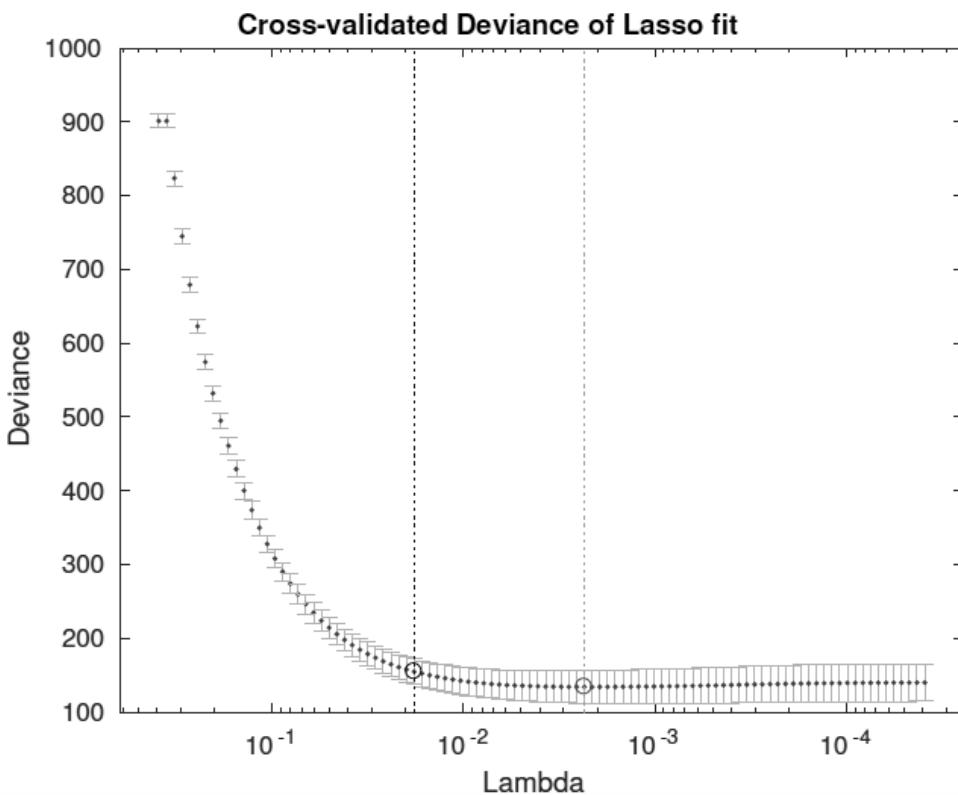
Insights from interpretable machine learning algorithms like random forests can inform decisions in the clinic. The top predictors in random forests are shown in Figure 10. Uniformity of cell size (2<sup>nd</sup> feature) and bare nuclei (6<sup>th</sup> feature) are important predictors. Mitoses (9<sup>th</sup> feature) is the least important predictor. We note however that mitoses separates two different clusters in the PCA plot (Figure 2) and may be useful as a biomarker.

We note that even though artificial neural networks have the best performance (cross-validation mean squared error = 0,01 for neural networks; cross-validation mean squared error = 0,04 for random forests), the most interpretable models are random forests.

We also used a logistic regression model with LASSO (*L*1 regularization). We performed 10-fold cross validation to determine the regularization parameter (Figure 11). We found that



**Figure 10.** Top predictors in a random forest algorithm.



**Figure 11.** A plot of the effect of changing the regularization parameter (lambda) in a logistic regression model with LASSO ( $L_1$  regularization). The cross-validation error is used to find the optimal value of lambda.

all predictors are non-zero after cross-validation. Hence the logistic regression model suggests that all the predictors are important.

Finally, we also looked at linear regression models for correlations of attributes with each other (within patients). We did not observe any meaningful relationships.

## Biomarkers

The predictors uniformity of cell shape and single epithelial cell size separate the data into a few different clusters in the PCA plot (Figure 2). Mitoses separates the data into a third cluster in the PCA plot (Figure 2). Bare nuclei is an attribute that accounts for some outliers in the PCA analysis (see Section 4.1 Stratifying Patients).

Our random forest algorithm suggests that the top predictors are uniformity of cell size and bare nuclei (Figure 10). Taken together, we suggest that uniformity of cell size and bare nuclei maybe important biomarkers for disease.

## DISCUSSION AND CONCLUSION

Big data technologies coupled with massive clinical records databases opens possibilities for data science in the clinic. Machine learning techniques coupled with clinical big data are thought to be critical in delivering the next generation of healthcare [2].

Here we present an automated machine learning framework that generates insights from clinical data with minimal operator intervention. The computational framework presented here can be used to stratify patients, predict disease severity and propose novel biomarkers for disease. This can be used to guide therapy and intervention in the clinic.

We use a suite of machine learning algorithms to predict disease severity and stratify patients. We found that a PCA analysis combined with random forests can suggest biomarkers and ways to stratify patients. Our analysis suggests that uniformity of cell size and bare nuclei maybe important biomarkers for disease.

Even though artificial neural networks have better performance predicting disease severity than random forests, the most interpretable models are random forests. This is critical in communicating these insights to clinicians and healthcare professionals who may not be machine learning experts. We show a representative rule from a tree in a random forest (Figure 9) which takes the form (1).

Insights from interpretable machine learning algorithms like random forests can be very informative to clinicians. Our framework automatically performs model inference, cross-validation, model selection and generates insights into data with minimal operator intervention. Our models are also interpretable, allowing domain experts like clinicians (with minimal machine learning experience) to engage in model building. Coupling automated and interpretable machine learning techniques with clinical data may help guide therapy, personalize treatment and help clinicians understand the change in disease over time.

Our approach can be combined with multi-scale models [5-9]. Hybrid modelling approaches can be combined with machine learning techniques presented in the current work to gain mechanistic insights into disease, as has done previously for infectious diseases [10-12].

In summary, we present an automated and interpretable machine learning framework for generating insights. We demonstrate how this computational framework can be applied to clinical data. Computational techniques like these can be used in translational medicine in close collaboration with clinicians and healthcare providers. Our approach is a step towards automated machine learning and computational biology in the clinic.

## **ACKNOWLEDGEMENTS**

The author wishes to thank Joyeeta Ghose, Dr. Beverly Kloeppe and Dr. Stephen Haben for fruitful discussions.

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# PREDICTING THE STRENGTH OF ONLINE NEWS FRAMES

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DOI: 10.7906/indecs.15.3.5  
Regular article

Received: 9<sup>th</sup> July 2017.  
Accepted: 23<sup>rd</sup> October 2017.

## ABSTRACT

Framing theory is one of the most significant approaches to understanding media and their potential impact on publics. Leaving aside that fact, the author finds that publicity effects seem to be dispersed and difficult to catch for public relations. This article employs a specific research design, which could be applied to public relations practice, namely with a view to observing correlations between specific media frames and individual frames. The approach is based on the typology of news frames. The author attributes negative, positive and neutral determinants to the types of frames in his empirical research. Online news regarding three transport organizations and the accompanying user comments (identified as negative, positive and neutral) are analysed by means of the method of content and sentiment analysis. The author recognizes user comments and reviews as individual frames that take part in the creation of online image. Furthermore, he identifies the types of media frames as well as individual frames manifested as image, and undertakes correlation research in order to establish their prediction potential. The results expose the most frequently used types of media frames concerning the transport domain. The media are keen to report through the attribution of responsibility frame, and after that, through the economic frame and the conflict frame, but, on the other hand, they tend to neglect the human interest frame and the morality frame. The results show that specific types of news frames enable better prediction of user reactions. The economic frame and the human interest frame therefore represent the most predictable types of frame.

## KEY WORDS

framing theory, user comments, online news, transport, sentiment analysis

## CLASSIFICATION

JEL: L82

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## INTRODUCTION

Measuring of PR effectiveness is important because it proves that public relations professionals produce value for the organization. This value is not tangible and visible at first sight. As contemporary public relations are above all strategic, the idea of measurement by objectives has become a standard for different evaluation types. Many authors [2, 3] agree that PR goals and outcomes are set on these levels:

1. Cognitive (refers to thoughts, opinions, consciousness) – it implies informing target publics about a certain topic, stimulating thoughts, awakening the existence of an issue, rising awareness
2. Affective (refers to emotions) – the activities are focused on shaping opinions and attitudes and provoking emotional reactions concerning a certain issue
3. Conative (refers to behaviour and doing) – it includes encouraging behaviour of target publics towards a certain direction.

In the context of media relations, public relations effectiveness should be measured primarily on the cognitive level and on the affective level. The conative level is characterized by too many interventions of different variables, which makes it hard to control. Therefore, associating behaviour with media effects turns out to be more complex. Kim [4] explains that it is necessary to correlate PR activities with financial benefits for the organization. It is crucial to reach the bottom-line impact of public relations efforts which could be described through reputation measurement and measurement of impact on income. Reputation is in this light defined as an integrated symbolic and behavioural relationship between corporate PR and target publics [4], while image is, according to [5] determined and lies on a symbolic relationship between the organization and target publics, being thus a middle step for reaching and measuring bottom-line impact of public relations. The image and extensively reputation form an outcome for public relations and present an independent variable for measuring PR impact on income (see also [6]). Marklein [7] points out that contemporary public relations experts should take into account ‘reach’ (as a potential that content will be seen by a certain number of users), ‘engagement’ (as user reaction to exposure) and ‘relevance’ (as content significance) for media metrics. The combination of these three communication dimensions should provide meaningful results on PR outcomes rather than just evaluating media coverage and reach. When it comes to PR outcomes, Macnamara [8] gives an overview of terms used for PR and social media measurement in contemporary practice: 1. ‘engagement’, 2. ‘influence’, 3. ‘impact’, 4. ‘awareness’, 5. ‘attitudes’, 6. ‘trust’, 7. ‘loyalty’, 8. ‘reputation’, 9. ‘relationships’, 10. ‘return on investment’ (ROI). From there on, it is clear that standardization in public relations measurement is required for PR professionals but also for the purpose of presenting the campaign results to the boards with more clarity. As shown, there are various outcomes of PR campaigns that need to be described more precisely. Zerfass's et al. [9] research shows that the diffusion of current academic knowledge of PR methodology represents a weakness when it gets transferred into PR practice. It is possible to conclude that standardization is necessary for PR research and evaluation.

Kim [4] in his regression analysis found a statistically significant correlation between reputation and organizational income. In the context of predicting consumer behaviour and associating it with profit, it is necessary to discuss behavioural economics [10] and related decision-making theories which can be useful for setting an evaluation model in public relations. Behavioural economics deals with cognitive elements that can influence decision-making and their relationship with certain behaviour. It can also be associated with

contemporary ideas of neuroeconomics and neuromarketing. Jelić [11] mentions some of the methods and tools that are used in neuromarketing: electroencephalography – monitoring of the electrical impulses in the brain; positron emission tomography – scanning and measuring various body functions; functional magnetic resonance – measures brain activity and brain blood flow; eye tracking glasses – measures direction of the eye, openness of the pupil and fixation length which can be correlated with different cognitive processes; physical manifestations – breathing speed, heart rate, perspiration. Tversky [12] developed some of the principles of behavioural economics by relying on the concept of framing.

Scheufele and Tewksbury [13] point out that framing is significantly different from agenda-setting theory because it is focused on the representation of the story in the news and on the influence it may have on the media consumers (see also [14-16]). The agenda-setting theory is focused on what to think about, but not explicitly what to think of a certain issue [17]. On the other hand, framing is a much more suitable theory for public relations professionals and PR measurement because it assumes that the media framing (a certain news perspective in the story) will affect and eventually change the individual frame of a media consumer on a certain topic. The framing theory existence is necessary for the comprehension of the way how individuals manage everyday situations and process information. The frame as a derivate of framing theory represents a 'mental map' [18] which allows an individual to manage and store experience. Framing theory is seen as a more refined version because it takes into account change in opinion and attitude. Therefore, it is also known as 'second-level agenda-setting' (as written by McCombs, cited in [13]; p. 11). Raupp [19; p.4] points out that PR effects in media relations are: "effects on the media presence of organizations and issues, effects on the tone and framing of the coverage, and effects on organizational reputation".

This research design relies on the types of media frames as presented in [1]. The centre of the news release amounts to the media frame which gives its story a clear determinant and purpose. It is possible to identify five types of frames used in media reporting [1]:

1. Conflict frame – this type of media frame emphasizes the conflict in the story between two or more sides, whether they are individuals, groups or institutions. This approach is one of the ways of drawing media consumers' attention.
2. Human interest frame – it is the media frame which includes a human example and emotion. The frame personalizes, dramatizes news and provokes emotion to keep interest of media publics
3. Economic consequences frame – this frame includes media reports about an event, an issue or a topic through economic indicators and consequences for an individual, a group, an institution or a country. It is a frame that puts finance in the centre as an element for attracting publics.
4. Morality frame – it is a type of media frame which puts an event, an issue or a topic in the context of religious and moral principles. In regard to the journalism principle of objectivity in reporting, this frame is recognized in statements of various sources of information.
5. Attribution of responsibility frame – the media frame presents a topic in a way that assigns responsibility for a cause of a problem to an individual, a group or the government or as a solution.

There is a rise of news portals which attract various publics, with respect to growth in number of users. Nowadays there is not a television or radio station, or even a newspaper without an online edition or a modified news site. As the readership, viewership and listenership are moving from traditional media towards social media, interactivity of the Web 2.0 became a serious reason for transferring public relations online. Chung suggests that in interactive news presentation there exist four styles:

1. Presentation of the news with the possibilities which allow users to experience news through different options and modalities – for example, selecting and deselecting news content
2. Presentation of the news with the possibilities of personalization and content shaping
3. Presentation of the news with the possibilities of modifying content in terms of adding user's own comments and expressing opinions
4. Presentation of the news with the possibilities of interpersonal communication with other users

This article is especially focused on user opinions and their comments as reactions to the article published online. Furthermore, the sum of their opinions towards organizations in the transport domain is interpreted as the online image or 'cyber image' [20]. The assumption is that the transport domain is a very fruitful research matter because of frequent oscillations in reporting caused by crises such as accidents, delays and weather. The question arises whether it is possible to predict user reactions and handle the online image on the basis of online news and the media frame involved. These findings could lead one step closer to associating public relations efforts with financial value.

## MATERIAL AND METHODS

### RESEARCH OBJECTIVES

- Identify and assess the media frames when reporting on Croatian organizations of the transport domain on online news sites.
- Assess user comments on online news sites as reactions to online media reports on Croatian transport organizations.
- Correlate media frames present in online new reports on Croatian transport organizations with user comments expressed as online image variants.

### RESEARCH QUESTIONS

- Which media frames in online media reports on Croatian transport organizations are represented more and which ones are represented less?
- What is the online image of Croatian transport organizations among users of online news sites?
- What is the correlation between the media frames in online reports on Croatian transport organizations and their online image?

### HYPOTHESIS

The existence of a moderate-strong positive correlation between media frames present when reporting about transport and user comments on online news sites – this hypothesis is tested on the examples of three Croatian organizations from the transport domain.

### SAMPLE

The unit of analysis in this correlation research makes online news report (news release) on *Croatia Airlines (CA)*, *Croatian Railways (HŽ)* and *Zagreb Electric Tram (ZET)*. For the other correlate, the unit of analysis is one user comment which belongs to the online news report on *Croatia Airlines*, *Croatian Railways* and *Zagreb Electric Tram*. The period of analysis on online news sites *24sata.hr* and *Index.hr* encompasses two years (from January 1, 2013 to December 31, 2014). The author selected this period with the intention to get varieties of data (strikes, delays, accidents, negative financial situations that were present in

that period of time). *24sata.hr* and *Index.hr* online news sites are recognized as the ones with highest user engagement as well as reach in that period of time. The simple random sample was taken from the population consisting of all news releases dealing with *Croatia Airlines*, *Croatian Railways* and *Zagreb Electric Tram*, which were published by the web portals *24sata.hr* and *Index.hr* during the analysed period (from January 1, 2013 to December 31, 2014). The sample consists of at least 30 % of units of analysis which make the whole population for each aforementioned transport organization (*Croatia Airlines* 2013/2014 –  $N = 102$ ; *Croatian Railways* 2013/2014 –  $N = 106$ ; *Zagreb Electric Tram* 2013/2014 –  $N = 106$ ). The accompanying user comments were extracted on the basis of the expressed opinion towards three transport organizations. Multiple comments of the same user in a single online news release and other comments not concerning these organizations were isolated. The user comments pertaining to a single news release were summed and presented through a dominant represented opinion (image) – positive, negative or neutral. The number of user comments varied in news releases. The overall sample of analysed comments is 3,068.

## METHODS

The method of content analysis is used for identifying and assessing media frames within the online news, while human sentiment analysis [21-23] was applied to user comments. Sentiment (human) analysis in the context of public relations can be understood as “analysis of a comment or post, aiming to determine the attitude of the speaker towards a brand or topic”. Moreover, the sentiment analysis shows what “people feel about a subject or brand, often expressed in simple terms as positive, negative or neutral”.

Media frames are identified in online news releases with the coding scheme based on [1]. There is a possibility of the presence of more than one media frame in certain news releases, however in this correlation research only the dominant frame is taken into consideration. The dominant frames are identified by using a scale from 0 to 1 for positive answers (0 – without positive answers; 1 – all positive answers). Two trained coders were engaged for conducting research. The Holsti reliability test [24] was used on twenty randomly selected online news releases from population and the achieved result was 0,89. Landis and Koch [25; p.165] suggest that inter-coder reliability from 0,81 to 1,00 belongs to the category of almost perfect. The same test was conducted on one hundred user comments from selected population with the result of 0,97. Further disagreement between coders was discussed. Each of the identified media frame was attributed as negative, positive and neutral. For providing trustworthiness of these attributes, the categories on the scale from extremely positive to extremely negative were determined as follows:

1. Extremely positive implies that three out of three entries are confirmed: there is no negative journalist opinion towards organization; the information sources express a positive opinion towards the organization; the reporting event is positive for the organization.
2. Positive implies that two from three entries are confirmed: there is no negative journalist opinion towards organization; the information sources express positive opinion towards the organization; the reporting event is positive for the organization.
3. Neutral implies that: there is no negative nor positive journalist opinion towards the organization; the information sources do not express positive nor negative opinion towards the organization; the reporting event is neither positive nor negative for the organization.
4. Negative implies that two out of three entries are confirmed: there is no positive journalist opinion towards organization; the information sources express a negative opinion towards the organization; the reporting event is negative for the organization.

5. Extremely negative implies that three out of three entries are confirmed: there is no positive journalist opinion towards the organization; the information sources express a negative opinion towards the organization; the reporting event is negative for the organization.

## VARIABLES

In this research the correlation is determined between:

The predictor variable – dominant media frame in online news reports by *24sata.hr* and *Index.hr* on *Croatia Airlines*, *Croatian Railways* and *Zagreb Electric Tram*. Media frames are attributed as positive, negative and neutral and categorized as follows: 1. Conflict frame, 2. Human interest frame, 3. Economic consequences frame, 4. Morality frame 5. Attribution of responsibility frame.

The criterion variable – user comments accompanying the online news reports by *24sata.hr* and *Index.hr* on *Croatia Airlines*, *Croatian Railways* and *Zagreb Electric Tram*. User comments are determined as positive, negative and neutral online image.

The correlation will be determined with the Pearson's coefficient on the interval from -1 to 1. A positive value of the correlation coefficient shows variable change in the same direction, (for predictor and criterion variables), on the other side a negative correlation coefficient indicates the opposite directions of prediction and criterion variables.

The correlation will be determined with the Pearson's coefficient on the interval from -1 to 1. A positive value of the correlation coefficient shows variable change in the same direction, (for predictor and criterion variables), on the other side a negative correlation coefficient indicates the opposite directions of prediction and criterion variables.

## RESULTS

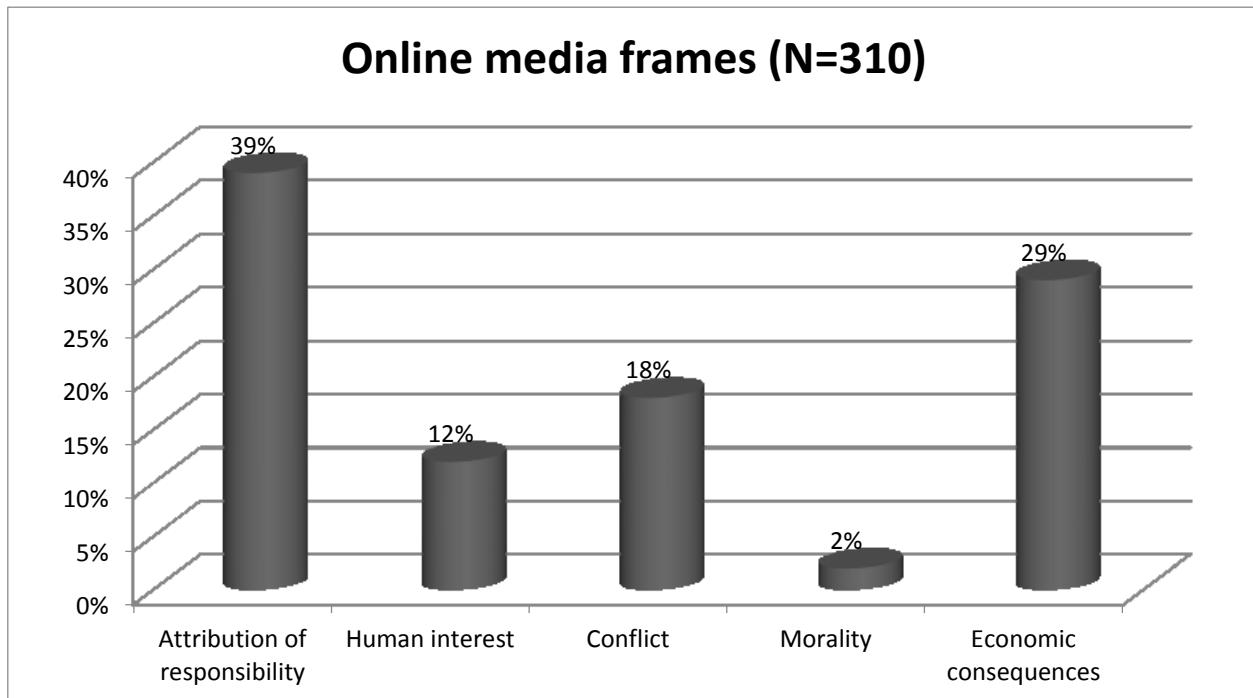
In their research Semetko and Valkenburg [1] analysed in what way the media reported on European politics and their findings showed that most of the news were framed through attribution of responsibility, conflict, economic consequences, human interest and, in the end, morality. The results in this primary research show a certain pattern or matching in media reporting. The application of the foregoing principle when applied to the transport domain, as exemplified by the three transport organizations, is presented mostly through attribution of responsibility (39 %), economic consequences (29 %), conflict (18 %), human interest (12 %) and morality (2 %) (Figure 1).

The presence of media frames when reporting on transport indicates that there are different media approaches concerning these organizations. The reports are specific for each organization (Table 1).

In the reports on *Croatia Airlines* the frame of economic consequences is the most frequent (34 %), illustrated in the article “For the First Time in Five Years: Croatia Airlines Runs Without Loss” (*24sata.hr*, 16.2.2014). This article reports positively on the profit of almost 670 000 kuna<sup>1</sup> for *Croatia Airlines*, and turnover in comparison with the year 2011 when the loss was 488,17 million kuna. Frame of economic consequences was attributed also negatively in the example “Slavko Linić<sup>2</sup> Cuts of Salaries” (*24sata.hr*, 4.11.2013) where *Croatia Airlines* losses in past years and high directors’ salaries in state firms are mentioned. In addition, a similar example of the negative economic frame is the article entitled “Croatia Airlines in First Six Months Had a Loss of 37,7 Millions” (*Index.hr*, 29.7.2014).

The conflict frame (23 %) is the second most frequent in the case of *CA*. This kind of reports is mostly associated with the employees strike and dispute with the board of directors in *CA*, which is confirmed by the following example: “Union vs. Board: In Croatia Airlines Attitudes

Aligned, Strike to End?" (*Index.hr*, 19.5.2013). However, the conflicts between *CA* crew and passengers were also a central topic "Carl Bildt<sup>3</sup> Furious: 'I Went to Dubrovnik and Ended up in Split'" (*24sata.hr*, 11.7.2014).



**Figure 1.** Overall frequency of media frames.

**Table 1.** Online media frames frequency per organization (N=310).

Types of frames	Attribution of responsibility	Human interest	Conflict	Morality	Economic consequences
<i>Croatia Airlines</i>	22 %	18 %	23 %	3 %	34 %
<i>Zagreb Electric Tram</i>	62 %	8 %	12 %	1 %	17 %
<i>Croatian Railways</i>	34 %	11 %	18 %	1 %	36 %

Attribution of responsibility (22 %) in the case of *CA* points out the Government's role in solving the financial problems of the Croatian national airline "Hajdaš Dončić<sup>4</sup> Travels to Indonesia to Discuss Croatia Airlines Sales" (*Index.hr*, 21.8.2013). Human interest frame (18%) was used for reporting in the positive light in the article entitled "25 Lucky Croatia Airlines Passengers Take Amsterdam Trip" (*24sata.hr*, 14.12.2014). The morality frame is rarely used, i.e. in only 3 %.

*Zagreb Electric Tram* is frequently presented through attribution of responsibility (62 %), followed by economic consequences (17 %), human interest (12 %) and morality frame (1 %).

When it comes to attribution of responsibility, responsibility is often assigned to persons involved in traffic accidents "ZET Bus Bursts into Flame in Sesvete<sup>5</sup>" (*24sata.hr*, 21.11.2014), "Berlingo Goes through Red Light and Crashes into Tram" (*24sata.hr*, 29.11.2014) and "Police Seeking Accident Witnesses" (*24sata.hr*, 21.11.2014).

Economic consequences are often related with rides without tickets in public transport, ticket prices and penalties as in the following examples: "Rides without Tickets to be Fined 1000 Kuna" (*24sata.hr*, 8.4.2013) and "Bandić<sup>6</sup>: Tram Tickets 30 % Cheaper, not yet Yearly Tickets" (*24sata.hr*, 8.4.2013).

The conflict frame is associated with the confrontation between *ZET* employees and passengers: "Bus Driver Refuses to Open Front Doors, Passenger Attacks Him" (*24sata.hr*, 18.4.2013.). Human interest is used for positive *ZET* presentation as in example "They Paid Tickets: Bride and groom Go to Wedding by Tram" (*24sata.hr*, 31.10.2014).

When it comes to *Croatian Railways*, the frame of economic consequences is mostly represented (36 %), following attribution of responsibility (34 %), conflict (18 %), human interest (11 %) and morality frame (1 %).

Investments are often mentioned through the economic consequences as in the example "In the Year 2014 the Investment Wave Worth 73 Billions Kuna is Starting" (*24sata.hr*, 12.12.2013), but also negative financial results "Government Takes Over HŽ Debt of 1,77 Billion Kuna, Housing Savings to be Boosted with 245 Kuna" (*Index.hr*, 23.12.2014).

Attribution of responsibility often refers to the Croatian government and the ministry in charge, which is responsible for solving *HŽ* problems: "Exhilarated Leko<sup>7</sup>: Best Fried Chicken is in Railways" (*24sata.hr*, 20.3.2014) and "Hajdaš Dončić Announces Railway Construction with EU Funds, Stanić Replies: It is Easy to Make Promises without Responsibility" (*Index.hr*, 22.10.2014).

The conflict frame is related to confrontations between the Croatian Government and *HŽ* employees as in the example "HŽ Cargo Workers Protested in Front of the Government and Announced Strike: We Know How to Work, but You Don't Know How to Manage" (*Index.hr*, 27.2.2014). Human interest is used in negative *HŽ* presentation in the examples such as "Train Full of Children Derails, but HŽ doesn't Report Accident because 'It is not Important'" (*24sata.hr*, 19.7.2013). The article reports about "frightened" children and a "calm" train driver.

While reporting on these three transport organizations (Table 2) through the conflict frame is formed mostly negative presentation of organizations (79 %). The morality frame is the most positive (60 %), but it is less frequent for making conclusions. Therefore, the human interest frame should be considered as the most positive for organizations (40 %). Nevertheless, the economic consequences frame is also partly positive for organizations (25 %). The attribution of responsibility frame is mostly neutral for organizations (53 %). Table 2 shows that the presentation of organizations in online news is predominantly negative.

**Table 2.** Organizational presentations in the online media frame.

Attribution values	Positive	Negative	Neutral
Attribution of responsibility, N=122	13 %	34 %	53 %
Human interest, N=38	40 %	47 %	13 %
Conflict, N=54	4 %	79 %	17 %
Morality, N=5	60 %	20 %	20 %
Economic consequences, N=91	25 %	44 %	31 %

User comments are assessed as positive, negative and neutral. These online opinions represent the organizational online image. They are actually direct reactions to online news and therefore through the sum of user comments, for each news release, the dominant image is identified. The most predictable frame is human interest (48 %) when it comes to identifying common individual and media frames concerning positive image. The human interest frame is based on the reports about satisfied passengers and employees. Secondly, the economic consequences frame is also responsive in terms of positive reactions. It reports about positive financial results and benefits for passengers. Nevertheless, statistical average (mean) shows that online image is

dominantly negative for Croatian transport organizations (55,67 %) (Table 3), then follows the neutral (37,3 %) online image and the positive one (7 %).

**Table 3.** Online image per media frame (N=310).

Attribution values	Positive	Negative	Neutral
Organizational image through user comments	7 %	55,67 %	37,3 %

The correlation analysis determined the relationship between predictor and criterion variables in the set of variables which refer to the evaluation of online news through media frames, as predictor variables, and user comments (online image), as criterion variable.

The significance of correlation coefficient indicates the existence of the statistically significant relationship between variables which are in this article observed on the level of 1 %. This describes model representativeness with uncertainty of 1 % ( $p < 0,01$ ).

The correlation of media frames and online image is shown in Table 4 and described with the Pearson correlation coefficient  $r = 0,364$ . This is determined as a moderate-strong positive correlation with uncertainty of 1 %. From these results it is possible to deem that the research hypothesis is confirmed.

**Table 4.** The correlation between online media frames in the transport domain and online organizational image.

Pearson Correlation (N=310)	Criterion Variable – online organizational image (user comments)	
	Coefficient	Significance
<b>Predictor Variable</b> – online media frames in reports on <i>CA</i> , <i>HŽ</i> and <i>ZET</i>	<b>0,364</b>	<b>p &lt; 0,001</b>

The hypothesis is confirmed for each transport organization included in this research. The correlation of media frames on *CA* and *CA* online image shows a moderate-strong positive relationship,  $r = 0,313$ , with uncertainty of 1% (Table 5).

**Table 5.** The correlation between online media frames on *CA* and *CA* online image.

Pearson Correlation (N=102)	Criterion Variable – <i>CA</i> online image (user comments)	
	Coefficient	Significance
<b>Predictor Variable</b> – online media frames on <i>CA</i>	<b>0,313</b>	<b>p &lt; 0,001</b>

The Pearson correlation coefficient  $r = 0,389$  in the case of *HŽ* indicates also a moderate-strong positive relationship on the level of 1 % (Table 6).

The highest correlation coefficient is marked in reports on *ZET* where the relationship between media frames and online image is  $r = 0,402$ , with significance of 1 % (Table 7).

**Table 6.** The correlation between online media frames on *HŽ* and *HŽ* online image.

Pearson Correlation (N=106)	Criterion Variable – <i>HŽ</i> online image (user comments)	
	Coefficient	Significance
<b>Predictor Variable</b> – online media frames on <i>HŽ</i>	<b>0,389</b>	<b>p &lt; 0,001</b>

In regard to types of frames, the results show (Table 8) the highest correlation between the economic consequences frame and online image,  $r = 0,375$ . This is a moderate-strong positive relationship with significance of 1 %. The human interest frame comes second with the correlation coefficient  $r = 0,372$ , which is a moderate-strong positive relationship on the level of 1 %. The correlation coefficient of the attribution of responsibility frame is lower and represents a weak positive relationship,  $r = 0,237$ , with the significance of 1%. In the end, the conflict frame proved to be the most unreliable in predicting user reactions because of a weak positive relationship ( $r = 0,160$ ) and with an unsatisfactory significance.

**Table 7.** The correlation between online media frames on *ZET* and *ZET* online image.

Pearson Correlation (N=102)	<b>Criterion Variable – <i>ZET</i> online image (user comments)</b>	
	Coefficient	Significance
<b>Predictor Variable – online media frames on <i>ZET</i></b>	<b>0,402</b>	<b>p &lt; 0,001</b>

**Table 8.** The correlation per frame with online organizational image.

Pearson Correlation (N=310)	<b>Criterion Variable – Online organizational image (user comments)</b>	
	Coefficient	Significance
<b>Predictor Variable – online media frames</b>		
Morality	0,839	0,076
Attribution of responsibility	<b>0,237</b>	<b>p &lt; 0,001</b>
Human interest	<b>0,372</b>	<b>p &lt; 0,005</b>
Conflict	0,160	0,248
Economic consequences	<b>0,375</b>	<b>p &lt; 0,001</b>

## DISCUSSION

The implementation of framing theory in this research design was used for determining frequency of five media frames [1] in online news reporting on transport organizations and also for correlations between the media frames and user comments (online image). The results show that the attribution of responsibility is the most frequently used frame and also the most neutral for organizations. It is not surprising that the frame of economic consequences came second considering that profit and the financial situation is one of the prerequisites for a positive or negative organizational reputation. Soroka et al. [26] in his research shows that economic topics provoke much stronger public response/reaction when there is negative information. The conflict frame is the most negative for organizations and follows the trend of negativity in mainstream media reporting. The human interest frame could be observed as very useful for organizations because of an often-positive approach in reporting. We can assume that users are keen to identify with persons involved in the reporting event and that kind of frame provokes sympathy and other positive emotions associated with organizations. The morality frame is not used in online media reporting and it seems that this approach does not sell news well enough. This kind of frequency also suggests which values are emphasized in society.

The correlation analysis showed that certain frames allow prediction of user reactions. Thus, the economic frame provides clear and precise data on business (positive or negative; growth or drop of income) and consequently users often have homogeneous opinions in this respect. The human interest frame proved to be good for predicting user reactions and the reason could be the users' identification with persons, satisfied employees and passengers, presented in the story.

In the example of attribution of responsibility the correlation coefficient is lower and unreliable for predictions. We could interpret that responsibility in reporting is abstract and fluid. Responsibility could be dispersing and depending on various user perspectives. Their viewpoints in determining responsibility for certain issue could be different than in media report. The conflict frame provides an even lower prediction possibility. Users can also choose sides in confrontation and they are not necessary the same as in the media report. In the Croatian transport domain frequent confrontations refer to the following relationships: employees-board, employees-passengers, employees-government. This study did not cover other domains (except transport) in media reporting. Therefore, this can be found as one of the limitations of the study.

## CONCLUSION

The research results show that it is possible to predict user reactions through a framing theory model. This research gives an insight into the fact that certain online media frames have more strength than the others, especially economic and human interest frame. They are responsive with user reactions therefore these findings could be used in public relations practice for preparing online news releases and managing organizational image and reputation through media. Considering that evaluation and measurement in public relations is one of the imminent challenges, this research design offers a concept and idea for further development of a standardised evaluation model through the use of framing theory in media. As pointed by Hallahan (cited in [19]; p.5), “the establishment of common frames of reference is necessary for building successful relations”.

Nowadays every organization in the corporate sector should take into account the importance of planned communication and strategic media relations. Moreover, media studies are in search for measurable connection between media and their effects on media publics, since there are many different variables that intervene in opinion-making process. These findings offer a viewpoint from where user comments, representing direct reactions to media content (news releases), are identified as a valuable PR and marketing research material for managing image and reputation, being thus very insightful for the creation of communication strategies within the organizations. Strategic framing should be taken seriously for media relations, as a part of corporate communication.

## REMARKS

<sup>1</sup>The Croatian national currency.

<sup>2</sup>The then Croatian Minister of Finance.

<sup>3</sup>A Swedish politician and diplomat.

<sup>4</sup>The then Croatian Minister of Maritime Affairs, Transport and Infrastructure.

<sup>5</sup>Zagreb's countryside.

<sup>6</sup>The then Mayor of Zagreb.

<sup>7</sup>The then Speaker of the Croatian Parliament.

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# AUTONOMOUS WHEELED MOBILE ROBOT CONTROL

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DOI: 10.7906/indecs.15.3.6  
Regular article

*Received:* 23<sup>rd</sup> August 2017.  
*Accepted:* 16<sup>th</sup> September 2017.

## ABSTRACT

The autonomous wheeled mobile robots are very interesting subject both in scientific research and practical applications. The article deals with the fuzzy control of autonomous wheeled mobile robotic platform motion in an unstructured environment with obstacles. The simulation results show the effectiveness and the validity of the obstacle avoidance behaviour in unstructured environments and the velocity control of a wheeled mobile robotic platform motion of the proposed fuzzy control strategy.

## KEY WORDS

autonomous wheeled mobile robots, fuzzy control strategy, unstructured environments, obstacles, simulation results

## CLASSIFICATION

ACM: D.1.1.

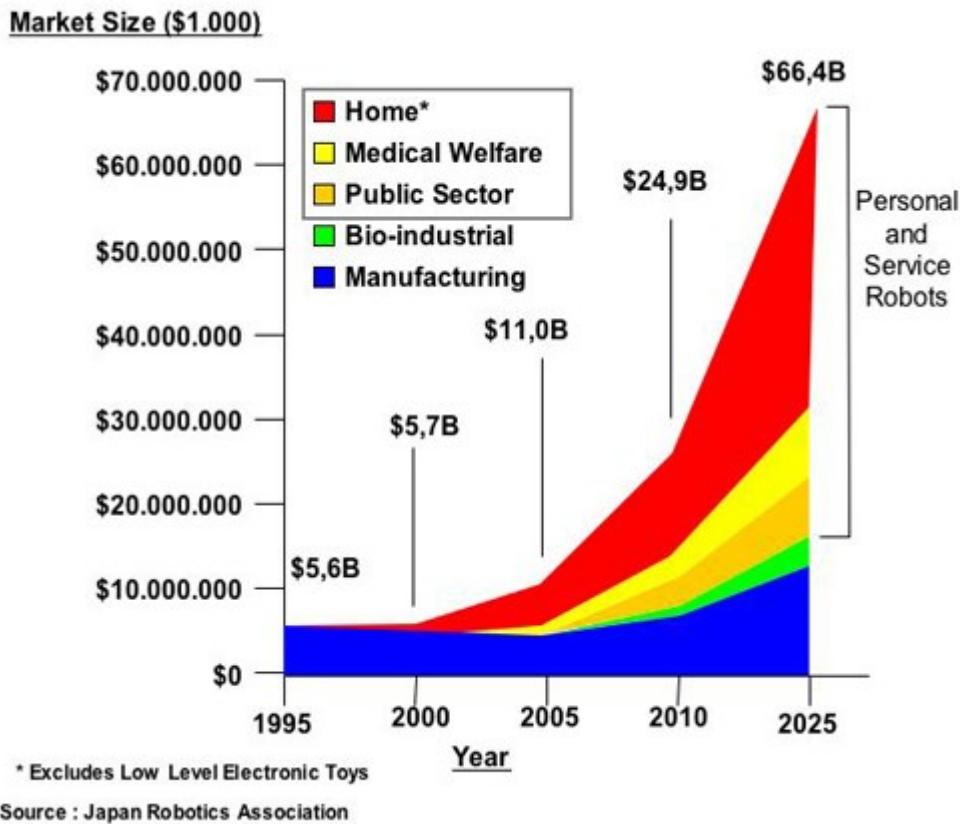
JEL: L64

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## INTRODUCTION

A wheeled mobile robot is a vehicle which is capable of an autonomous motion. The autonomous wheeled mobile robots are very interesting subject both in scientific research and practical applications [1-3].

Figure 1. show the recent situation and the future of the market size of the personal and service robots (source: Japan Robotics Association).



**Figure 1.** Market size of the personal and service robots.

The article deals with the fuzzy velocity control of an autonomous wheeled mobile robots motion in an unstructured environment with obstacles [4-9]. This article presents how to control of motion and velocity of wheeled mobile robots in an unstructured environment that contains obstacles with using ultrasonic sensors and a stereovision system.

The simulation results show the effectiveness and the validity of the obstacle avoidance behaviour in unstructured environment and velocity control of a wheeled mobile robot motion of the proposed fuzzy control strategy.

The article is organized as follows:

Section 1: Introduction.

Section 2: The structure of the general indoor/outdoor applications of mobile robots.

Section 3: Control strategy for wheeled mobile robots.

Section 4: Simulation results.

Section 5: Conclusions.

## THE STRUCTURE OF THE GENERAL INDOOR/OUTDOOR APPLICATIONS OF MOBILE ROBOTS

The structure of the general indoor/outdoor applications of autonomous mobile robots are presented in Table 1 and Table 2.

**Table 1.** Indoor applications of mobile robots.

Indoor/Structured Environments
Cleaning large buildings
Transportation industry and service
Research entertainment
Surveillance buildings
Customer support museums, shops

**Table 2.** Outdoor applications of mobile robots.

Outdoor/Unstructured Environments
Agriculture
Forest
Space
Underwater
Military
Fire fighting
Sewage tubes
Mining

## CONTROL STRATEGY FOR WHEELED MOBILE ROBOTS

In this section fuzzy control is applied to the navigation of the autonomous wheeled mobile robotic platform in unstructured environments with obstacles and slopes [10-15].

It is supposed that: the autonomous wheeled mobile robotic platform has two wheels driven independently and groups of ultrasonic sensors to detect obstacles in the front, to the right and to the left of the autonomous wheeled mobile robotic platform.

When the autonomous wheeled mobile robotic platform is moving towards the target and the sensors detect an obstacle, an avoiding strategy is necessary.

While the autonomous wheeled mobile robotic platform is moving it is important to compromise between:

- avoiding the obstacles and
- moving towards the target position.

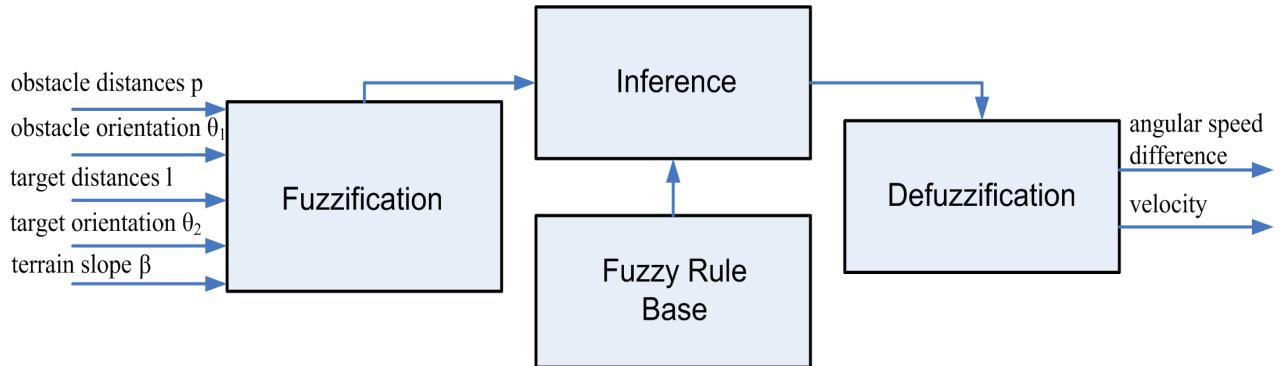
With obstacles present in the unknown environment, the autonomous wheeled mobile robotic platform reacts based on both the sensed information of the obstacles and the relative position of the target [16-23].

In moving towards the target and avoiding obstacles, the autonomous wheeled mobile robotic platform changes its orientation and velocity.

When an obstacle in an unknown environment is very close, the mobile robot slows down and rapidly changes its orientation. The navigation strategy has to come as near to the target position as possible while avoiding collision with the obstacles in an unknown environment.

The block diagram of the fuzzy inference system is presented in Figure 2.

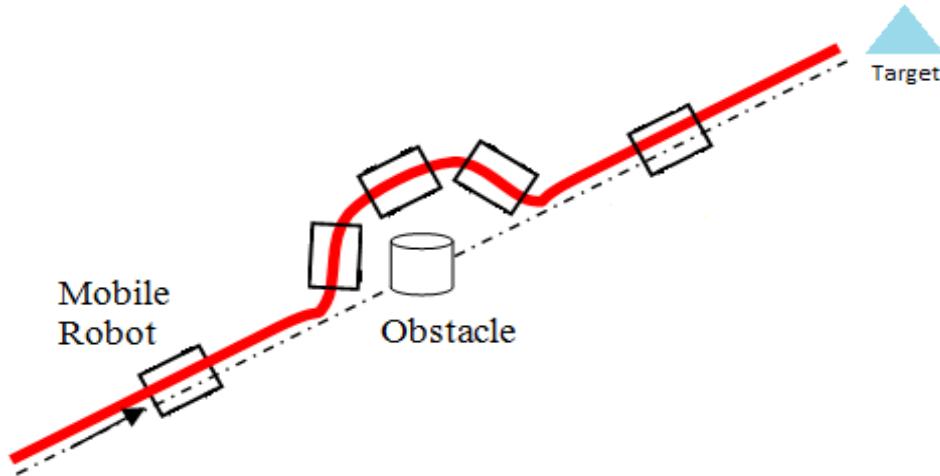
In the present implementation of the fuzzy controller the Center of Area method of defuzzification is used.



**Figure 2.** The block diagram of the fuzzy inference system.

## SIMULATION RESULTS

The author applied the proposed fuzzy controller to the autonomous wheeled mobile robotic platform moving in an unstructured environment with obstacles. The control strategy was tested through simulations of wheeled mobile robot motion [24-27]. A simulation example of a wheeled autonomous mobile robotic platform is presented in Figure 3. The corresponding fuzzy control is implemented to perform tasks of obstacle and collision avoidance. In particular, the navigation strategy proved to be extremely sensitive to the balance between avoid obstacle and reach the target behaviors. Simulation results are shown in Figure 3.



**Figure 3.** Obstacle avoidance trajectory of wheeled mobile robot platform.

## CONCLUSIONS

The article deals with the fuzzy control of autonomous wheeled mobile robotic platform motion in an unstructured environment with obstacles. The simulation results show the effectiveness and the validity of the obstacle avoidance behaviour in unstructured environments and the velocity control of a wheeled mobile robotic platform motion of the proposed fuzzy control strategy.

Wheeled mobile robot navigation strategies using fuzzy logic have major advantages over analytical methods also simulation results recommends fuzzy logic controller for the wheeled mobile robot motion in unstructured environments.

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## RANGIRANJE ISTRAŽIVAČA IZ BALTIČKIH DRŽAVA

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### **SAŽETAK**

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## **TALOŽNO STVARANJE STIJENA – PRIRODNI MODEL ADITIVNE PROIZVODNJE**

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### **SAŽETAK**

Sve stvoreno u prirodi rezultat je prirodne tehnologije. Rješenja iz prirode mogu biti poticaj za umjetnu, čovjekovu tehnologiju samog života (biotehnologiju) i tehnologiju biogeneze. Sukladno tome, u radu je postavljeno pitanje što je prirodni model za aditivnu proizvodnju tvorevina. Nakon geološke analize nekih proizvoda prirode i usporedbom s aditivnim tvorevinama načinjenih s pomoću čovjekovih umijeća ustanovilo se preklapanje. Prirodni model za proizvodnju aditivnih tvorevina je formiranje sedimentnih stijena prije 3,7 milijardi godina. Istodobno je napravljena sistematizacija aditivnih postupaka i aditivne proizvodnje, prve revolucionarne promjene u primarnom oblikovanju nakon 4,3 milijardi godina.

### **KLJUČNE RIJEČI**

prirodne stijene, prirodni model aditivnih postupaka, aditivni postupci, aditivna proizvodnja

# NUMERIČKA TEHNIKA PROCJENE ŽIVOTNOG VIJEKA STANICA INFICIRANIH RAZVIJAJUĆOM VIRUSNOM INFEKCIJOM

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## SAŽETAK

Nove vrste virusa izazivaju znatne nesreće kad prelaze na ljude s ostalih vrsta. Ovdje se razmatra novu tehniku za numeričku procjenu značajnog parametra virusne infekcije u organizmu: životni vijek inficiranih stanica. Pristup je općenit i može biti primijenjen na velik broj eksperimentalnih podataka o virusima dobivenim u proučavanju replikacije.

Određivanje životnog vijeka inficiranih stanica postojećim metodama je problematično zbog problema s identificiranjem i korelacijama parametara. Životni vijek inficirane stanice značajan je parametar na temelju kojega se procjenjuje brzina uklanjanja virusa. Metoda opisana u ovom radu omogućava određivanje jesu li inficirane stanice kratkoživuće ili dugoživuće. Dugoživuće inficirane stanice mogu biti spremnici infekcije. To daje mehanističko razumijevanje zašto su neke stanice spremnici infekcije i može motivirati terapiju usmjerenu na takve stanice. Metoda je primijenjena na virus Zapadnog Nila, jednu nastajuću epidemiju od interesa za javno zdravstvo, a koja je povezana sa Zika virusom. Analiza upućuje na to da su od svih stanica koje se mogu inficirati najbrojnije kratkoživuće, što može motivirati terapiju usmjerenu na takve stanice. Ovaj pristup je vrlo općenit i može biti kombiniran s tradicionalnim metodama temeljenim na sustavima diferencijalnih jednadžbi za simuliranje djelovanja virusa u organizmu. Kombinacija navedene dvije tehnike vjerojatno će dovesti do rezultata koji se ne može postići izoliranim modelima, što je od interesa za modeliranje razvoja zaraze.

## KLJUČNE RIJEČI

virusna oboljenja, virus Zapadnog Nila, istraživanja replikacije

# RAČUNALNA BIOLOGIJA S AUTOMATSKOM INTERPRETACIJOM U KLINICI: OKVIR ZA PREDVIĐANJE OZBILJNOSTI ZARAZE I GRUPIRANJE PACIJENATA NA TEMELJU KLINIČKIH PODATAKA

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## SAŽETAK

Rad opisuje okvir za automatsko računanje i strojno učenje koji predviđa ozbiljnost zaraze i prema tome grupira pacijente. Okvir koristi dostupne kliničke podatke. Algoritam automatski generira uvide i predviđa ozbiljnost zaraze, uz minimalno uključivanje operatera. Računalni okvir razvijen u ovom radu omogućava grupiranje pacijenata slijedom predviđanja ozbiljnosti zaraze, kao i uočavanje novih biomarkera zaraze. Uvidi dobiveni primjenom algoritama strojnog učenja u kombinaciji s kliničkim podacima mogu pomoći usmjeravanju terapije, individualizaciji pristupa i razumijevanju promjena zaraze u vremenu. Računalne tehnike poput ove mogu biti korištene u translacijskoj medicini u bliskoj suradnji kliničara i drugih zdravstvenih djelatnika. Model može biti interpretiran tako da u njegovom nadogradnjama mogu sudjelovati kliničari relativno malog iskustva sa strojnim učenjem. Ovaj je rad doprinos primjeni automatskog strojnog učenja u klinikama.

## KLJUČNE RIJEČI

predviđanje ozbiljnosti zaraze, strojno učenje, računalna tehnika, *big data*

# PREDVIĐANJE UČINKA ONLINE MEDIJSKIH OKVIRA

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## SAŽETAK

Uokvirivanje pripada u neke od najznačajnijih teorija za razumijevanje medija i njihovog potencijalnog utjecaja na javnosti. Pored toga, autor publicitet i njegove učinke promatra kao raspršene i teško uhvatljive za odnose s javnošću. Ovaj rad donosi specifičan dizajn istraživanja koji bi se mogao primijeniti u praksi odnosa s javnošću, s osobitim usmjerenjem na korelaciju medijskih okvira i individualnih okvira. Pristup je temeljen na tipologiji medijskih okvira. Autor u empirijskom istraživanju atribuirira tipove medijskih okvira s negativnim, pozitivnim i neutralnim odrednicama. Analiza sadržaja i sentimenta uključuju online vijesti koje izvještavaju o tri transportne organizacije i pripadajuće komentari korisnika (identificirane kao negativne, pozitivne i neutralne). Autor promatra korisničke komentare i recenzije kao individualne okvire koji sudjeluju u kreaciji online imidža. Nadalje, identificiraju se tipovi medijskih okvira kao i individualni okviri koji se manifestiraju kao imidž. Koreacijsko istraživanje služi za ispitivanje potencijala predviđanja na temelju medijskih okvira. Rezultati otkrivaju najfrekventnije tipove medijskih okvira u domeni transporta. Online mediji su prema tome skloni izvještavati kroz okvir odgovornosti, zatim okvir ekonomskih posljedica i okvir sukoba, a s druge strane često zanemaruju okvir ljudske priče i okvir moralnosti. Rezultati pokazuju da specifični tipovi okvira omogućuju bolje predviđanje reakcija korisnika. Okvir ekonomskih posljedica i okvir ljudske priče u tom smislu omogućuju najbolju predikciju.

## KLJUČNE RIJEĆI

teorija uokvirivanja; komentari korisnika; online vijesti; transport; analiza sentimenta

# UPRAVLJANJE AUTONOMNIM MOBILNIM ROBOTOM S KOTAČIMA

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## SAŽETAK

Autonomni mobilni roboti s kotačima zanimljivi su i za znanstvena istraživanja i za primjene. The article deals with the fuzzy control of autonomous wheeled mobile robotic platform motion in an unstructured environment with obstacles. The simulation results show the effectiveness and the validity of the obstacle avoidance behaviour in unstructured environments and the velocity control of a wheeled mobile robotic platform motion of the proposed fuzzy control strategy.

## KLJUČNE RIJEČI

autonomni mobilni robot s kotačima, strategija neizrazitog upravljanja, nestrukturirana okolina, prepreke, rezultati simulacije



# MANUSCRIPT PREPARATION GUIDELINES

Manuscript sent should contain these elements in the following order: title, name(s) and surname(s) of author(s), affiliation(s), summary, key words, classification, manuscript text, references. Sections acknowledgments and remarks are optional. If present, position them right before the references.

**ABSTRACT** Concisely and clearly written, approx. 250 words.

**KEY WORDS** Not more than 5 key words, as accurate and precise as possible.

**CLASSIFICATION** Suggest at least one classification using documented schemes, e.g., ACM, APA, JEL, PACS.

**TEXT** Write using UK spelling of English. Preferred file format is Microsoft Word. Provide manuscripts in grey tone. For online version, manuscripts with coloured textual and graphic material are admissible. Consult editors for details.

Use Arial font for titles: 14pt bold capital letters for titles of sections, 12pt bold capitals for titles of subsections and 12pt bold letters for those of sub-subsections. Include 12pt space before these titles.

Include figures and tables in the preferred position in text. Alternatively, put them in different locations, but state where a particular figure or table should be included. Enumerate them separately using Arabic numerals, strictly following the order they are introduced in the text. Reference figures and tables completely, e.g., “as is shown in Figure 1,  $y$  depends on  $x$  ...”, or in shortened form using parentheses, e.g., “the  $y$  dependence on  $x$  shows (Fig. 1) that...”, or “... shows (Figs. 1-3) that ...”.

Enumerate formulas consecutively using Arabic numerals. In text, refer to a formula by noting its number in parentheses, e.g. expression (1). Use regular font to write names of functions, particular symbols and indices (i.e. sin and not  $\sin$ , differential as  $d$  not as  $D$ , imaginary unit as  $i$  and not as  $I$ , base of natural logarithms as  $e$  and not as  $E$ ,  $x_n$  and not  $x_{\text{n}}$ ). Use italics for symbols introduced, e.g.  $f(x)$ . Use brackets and parentheses, e.g. {[ ( ) ]}. Use bold letters for vectors and matrices. Put 3pt of space above and below the formulas.

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**ISSN 1334-4684 (printed)**  
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