

Jakub Jernajczyk

## **Summary of Professional Accomplishments**

Wrocław 2018

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2008: MA in art, the Faculty of Graphic Arts, The Eugeniusz Geppert Academy of Art and Design in Wrocław, major: graphic design  
Tutors: Professor Ludwik Żelaźniewicz and Professor Ryszard Jędróś

2013: PhD in Fine Arts awarded by the resolution dated 2 December 2013 of the Council of the Faculty of Graphic Arts and Media Art at The Eugeniusz Geppert Academy of Art and Design in Wrocław,  
Doctoral thesis title:  
*Spaces of Discrete Motion. The Origin and Characteristics of the Discrete Illusion of Motion*  
Tutor: Professor Wiesław Gołuch  
Reviewers: Professor Jerzy Hejnowicz, Professor Stanisław Sasak

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4. In accordance with the formal requirements, as a paper aspiring to fulfill the conditions arising out of Article 16, section 2 of the Act of 14 March 2003 Act on academic degrees and academic title and degrees and title in art (Journal of Laws 65, item 595, as amended) I indicate:

**MathArt** – the cycle of multimedia installations

- *The Remainder (Reszta)*, video installation, animated loop HD, 2014
- *Zeno<sup>2</sup>*, video installation, animated loop HD, 2015
- *Definite Integral Figures (Ciałka oznaczone)*, video installation, animated loop HD, 2015
- *The Limits of a Circle (Granice Koła)*, video installation, animated loop HD, 2015
- *Inflection Points and Extrema (Przebiegięcia i ekstrema)*, video installation, animated loop HD, 2016
- *The Exhaustive Picture (Obraz wyczerpujący)*, video installation, animated loop HD, 2016

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## INTRODUCTION

This Summary of Professional Accomplishments is a presentation of my artistic, academic research, didactic organizational oeuvre, with particular focus on the multimedia cycle *MathArt* which I submit as my habilitation project in art. Similar to the majority of my art projects, the installations which comprise the *MathArt* cycle, draw inspiration from science, in this case – mathematics. The close relationship of art and science, that is how they interpenetrate and complement one another, is the main characteristic of my artistic endeavors in terms of creating art, as well as theoretical reflection which mainly pertains to the cognitive role of image and the cognitive role of art.

Image plays a superior role in human cognition which was already known by the ancient philosophers. According to Plato, observation of the world allows us to create abstract ideas (such as numbers and time) thanks to which it is possible to examine the nature of the world which finds its paramount form in philosophy.<sup>1</sup> Aristotle regarded senses, in particular the sense of sight, as the obligatory condition of any cognition stating that a human being "without sensation a man would not learn or understand anything."<sup>2</sup> Medieval philosophers, developing the concepts inherited from Plato, as the subtlest cognitive power regarded the so-called "mind's eye."<sup>3</sup> In the 20<sup>th</sup> century the thesis that perception and visual imagination play a key role in our cognition found its main advocate in the person of Rudolf Arnheim, the German psychologist and art theorist. In his classic masterpiece *Visual thinking*<sup>4</sup> he proved that not only our colloquial thinking but the entirety of science and math<sup>5</sup> included, builds its abstract ideas on the basis of visual connotations. If image is such a crucial aspect of cognition, then art, which is the natural domain of imaging, should play a leading part in shaping up our cognitive competences.

I fully agree with that statement and make it one of the fundamental assumptions of my creative work. In my projects I try to transform scientific content in a creative way in order to create art objects which not only influence the recipient with their aesthetic, audiovisual form, but also evoke the recipient's interest in the source theoretical issue. That cognitive synergy, which happens between art and science, will constitute the main axis of the deliberations included in this paper. In the cycle of multimedia installations *MathArt*, that synergy is particularly and explicitly present.

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1 Plato, *The Timaeus of Plato*, 47a-b, trans. R. D. Archer-Hind, Macmillan, London 1888, s. 163.

2 Aristotle, *De Anima*, 432 a, trans. R. D. Hicks, Cambridge University Press, Cambridge 1907, p.145

3 Nicholas of Cusa, *Idiota de mente (The Layman on Mind)*, [in:] id., *On Wisdom and Knowledge*, trans. J. Hopkins, The Arthur J. Banning Press, Minneapolis 1996, p. 573.

4 R. Arnheim, *Visual Thinking*, University of California Press, Berkeley, Los Angeles, London, 2004.

5 On the role of visual imagination in mathematics see M. Giaquinto, *Visual Thinking in Mathematics. An epistemological study*, Oxford University Press, New York 2007.

# I. IN BETWEEN – interdisciplinary creative path

## The beginnings...

If I had to describe my creative and research activities with one word, that word would be interdisciplinary. That feature was visible as early as in school because I went to a regular high school and to a music high school and as a result I took two graduation exams. Even then I was suspended between art and science, although at that time it didn't have the mutual interpenetration aspect (at least I was not fully aware of that); it also wasn't the art that I was going to devote myself to in the future.

From my youngest years I was strongly convinced that sooner or later I would end up in a Fine Arts Academy, although my university education started from a completely different angle – mathematics. During my student years at the University of Wrocław I still drew (as a hobby and as a profession – I did illustrations for magazines). In the middle of my studies I realized that I was also interested in philosophy and I started paying more and more attention to that topic.

In 2003 I defended my master's thesis entitled *Discrete analysis of the electroencephalographic signal*, written under the tutorship of Krzysztof Tabisz, Ph.D. and I received a Master's degree in mathematics (Major: mathematics in computer science). Only then, finally fully aware what I wanted to deal with, I started studying at the Faculty of Graphic Arts at the Wrocław Academy of Art and Design. During the first years of my studies, in parallel I ran research at the Technical University in Wrocław, I cooperated with Professor Mirosław Łątka in the area of digital analysis of biological signals. That constant suspension between at least two areas of study, at some point, caused the fact that in a natural way, I started looking for a way to link the various areas of my activities. As a result, I quite quickly directed my artistic endeavors to form a relationship with science. In that spirit, in 2006 I wrote a Bachelor's Thesis *Between art and science* (Tutors: Professor Eugeniusz Smoliński and Professor Wiesław Gołuch). A year later, still as a student I was hired as an assistant in the Media Art Department.

The first art projects in which the relationship of art and science achieved a mature form, in my opinion were the two works which were included in my Master's diploma *Pictures from philosophy* which I defended in 2008 under the tutorship of Professor Ludwik Żelaźniewicz and Professor Ryszard Jędroś. They were multimedia installations: *Lucretius spear* and *The Circle of Knowledge*. In these works in particular, for the first time the foundations of my future research became visible, the research triangle including: 1) theoretical and logical grounds in sciences (mainly mathematics), 2) creative transformation in the area of visual art and 3) the joining role of philosophy which creates a bridge between sciences and humanist areas, between science and art.

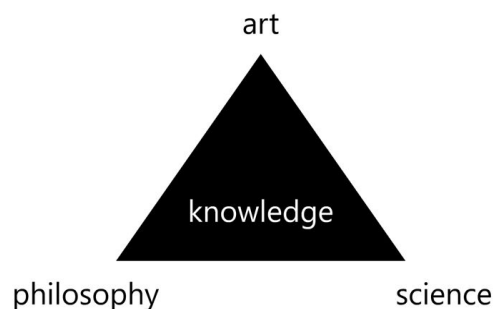
Although choosing philosophy as a natural joining power for creative work appealed to me intuitively, it was not a revelation at all. The joining power of philosophy was earlier explained by e.g. William James when he wrote that "By its poetry it appeals to literary minds"<sup>6</sup> whereas "By its logic it appeals to the scientific".<sup>7</sup> At the same time, it prevents the "poetic softening" of humanist minds and it softens "the stiffness" of scientific minds.<sup>8</sup>

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6 W. James, *Some Problems of Philosophy. A Beginning of an Introduction to Philosophy*, Longmans Green And Co., New York, 1916 p. 7-8.

7 Ibid

8 Comp. ibid



#### 01. Research triangle: art – science – philosophy

That mutual supplementing of art, science and philosophy was also one of the main motifs of my PhD thesis entitled *Spaces of Discrete Motion* which I defended at the Eugeniusz Geppert Academy of Art and Design, Faculty of Graphic Arts and Media Art in 2013 under the tutorship of Professor Wiesław Gołuch. In that work, in a creative way I referred to cognitive and epistemological aspects related to the structure and perception of a moving picture.

That researching and cognitive triangle of mathematics, art and philosophy is also the foundation of the habilitation work cycle *MathArt* described in this Summary.

#### Between art and science... cognition art

True interdisciplinarity I understand not as a superficial linking of multiple traits taken from many areas, but as a deep form of research carried out in each of the areas that are being researched, the effect of which is the union of seemingly distant issues gives birth to new quality. The key role in my works is played by the element of artistic creation, which enables a fresh – visual – view on classic scientific issues to appear. On the one hand, it allows for scientific content to exist in the field of art, on the other it provides a chance that the non-standard approach will also cast new light on the area of theoretical pursuits.

My work on the borderline between art and science might be naturally associated with the art&science trend. My approach to the relationship of these two disciplines is however expressly different. Artists who operate in the e.g. *bio art* field or *robotic art*, who often use very advanced technologies, scientific methodologies and laboratory equipment, usually create art projects in which the stress is laid purely on artistic effect. For example, Stelarc, one of the leading representatives of *art&science*, clearly distances himself from the attempts to give his art a scientific character. In his opinion, art and science have completely different goals and the thing that could link them is technology.<sup>9</sup> With all due respect to that approach, I have to state that I have a different aim for my art – apart from the artistic effect, I collaterally find the cognitive aspect to be not of less importance. In the words of Ryszard Kluszczyński, for me it is "about creating artistic phenomena, where aesthetic experience connects and merges with cognitive experience."<sup>10</sup> In that sense, I'm also opposed to the asemantic tendencies that are dominant in contemporary art, according to which a work of art should not depict or represent anything but that it should be a

9 M. Ożóg, *Interview with Stelarc*, [in:] *Meat, Metal & Code / Contestable Chimeras STELARC*, ed. R.W. Kluszczyński, Łaźnia Centre for Contemporary Art, Gdańsk 2014, p. 50-51.

10 R.W. Kluszczyński, *art@science. About Relations between Art and Science*, [in:] *Towards the third culture. The Co-Existence of Art, Science and Technology*, ed. id., Łaźnia Centre for Contemporary Art, Gdańsk 2011, p. 37.

purely visual phenomenon, dissected of any references and meanings.<sup>11</sup> My art, on the contrary, does not disconnect itself from external content by default. Although a moving image is supposed to draw attention, to attract by its visual form alone, we could say with "pure visuality," it is also supposed to be a carrier of meanings which go beyond the field of art.

The approach I propose may be in danger of the accusation, that art is here deprived of full autonomy, because it remains in close relationship with the scientific content or even that it serves science. It has to be emphasized that the relationship is reciprocal – art serves science to the same degree that science serves art. It serves it as a starting point, as the source of inspiration, and forms a field for justification and verification of the cognitive role of art. It is then more of a symbiotic relationship in which art and science interpenetrate and complement one another; a relationship in which between art and science, there's cognitive synergy. As a result, neither art serves science nor science serves art, but they each mutually serve thinking. Connected together they let us see with understanding and think visually.<sup>12</sup>

To describe this individual approach in which the creative element interpenetrates with and complements the cognitive one, as it is an approach which escapes the classic divisions into fields and disciplines, I took the liberty of creating a term *cognition art*.

### Selected art projects (2008 – 2013)

In this section I will present selected art works created in the time period between my Master's and PhD diplomas. I will focus on works for which the main source of inspiration were theoretical issues (scientific and philosophical) which aimed at familiarizing the viewer with those issues and at the same time emphasize the cognitive role of image and art. That is why I will not describe art projects which did not expressly refer to science problems (e.g. *FIBRAFON*, *ZAPIS*, or *CONCERTO COCCODÉ*), or commercial projects (logos, graphic designs, multimedia installations) although the experience I gained working on them also had a definite influence on the character of all my art, both aesthetically and technologically. I hope that the projects I've chosen will precisely show the consistent creative path which led to creating the multimedia cycle *MathArt*.

I will start with the two projects mentioned earlier which were a part of my Master's diploma: *Lucretius Spear* and *The Circle of Knowledge*. The first one is an interactive installation which refers to the famous reasoning of the Roman poet Lucretius (1st century BC) who by way of pure speculation proved that the universe is indefinite.<sup>13</sup> A fragment of a black circle is displayed on the screen, which in some states fits into the arcs drawn on the wall. Touching the rim of the circle augments it and as a result it turns out that the point that we touched was not on the rim but inside the circle. The limit of a circle, which symbolizes the universe, is constantly escaping us. The *Lucretius spear* won the Szczecin Mayor's prize during the 5th International Festival of Visual Art inSPIRACJE 09 and an honorary mention at the National Exhibition of Postgraduate Drawing in 2010 in Toruń.

The second of these diploma works – *The Circle of Knowledge* is a digital projection, which is a visual metaphor of the evolutionary process of human knowledge. The source of inspiration to create it were the epistemological deliberations pertaining to the geometry of Willard Van Orman

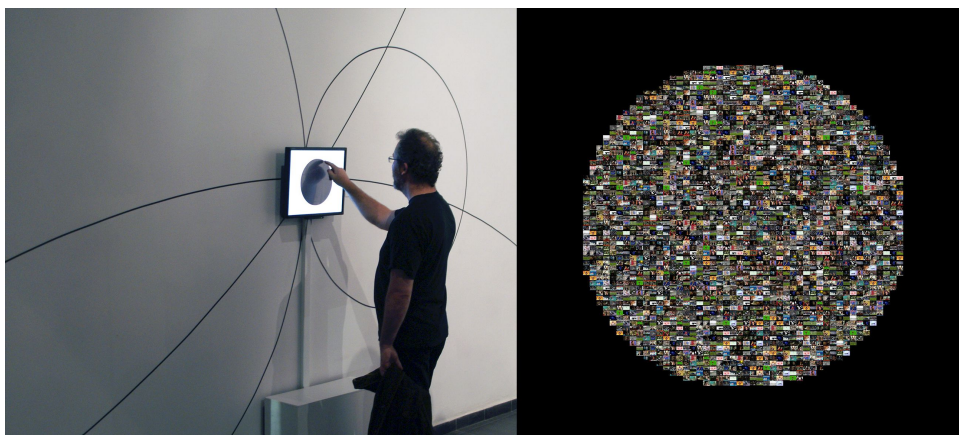
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11 Comp. P. Zawojski, *Sztuka obrazu i obrazowania w epoce nowych mediów*, Oficyna Naukowa, Warszawa 2012, p. 24-31.

12 Let me emphasize again that in the proposed approach I speak of the cognitive synergy of science and art. I do not have in mind the kind of art which is isolated from external content and associations. On the topic whether and in what sense art alone can play a cognitive role see in: P. Kozak, *Sztuka i myśl*, Fundacja na rzecz myślenia im. Barbary Skargi, Warszawa 2015, p. 160-197.

13 Lucretius, *On the Nature of Things*, trans. M. F. Smith, Hackett Publishing Company, Indianapolis 2001, p. 29.

Quine and Michał Heller.<sup>14</sup> The screen shows a figure made of square blocks which contain fragments of a moving television picture. As a result of subsequent divisions, the figure's shape more and more resembles a circle although it is clear that it is not exactly the same as a circle. At some point of its evolution, that figure consists of millions of moving elements. Composing this complex structure was possible thanks to a specific application written in the *Processing* language. After years of studies on cognitive visual metaphors, I returned to the ideas included in the project and I developed them further in the article *Circle and sphere – geometrical speculations in philosophy*.<sup>15</sup>



02. *Lucretius Spear* (2008), *The Circle of Knowledge* (2008)



03. *Wittgenstein's Mirror* (2010)

I continued the stream of art projects referring to philosophical problems, in 2010 at the inSPIRACJE 2010 GLAMOUR I presented an interactive installation *Wittgenstein's Mirror*.<sup>16</sup> At first glance it seems to be a simple arrangement of mirror tiles on the wall. Although close-up we begin to realize that you can look inside some of the elements to discover that some of them symbolize people's sins and weaknesses. Looking into the mirror we only see our reflection; looking inside the

14 W. V. Quine, *Two Dogmas of Empiricism*, „The Philosophical Review”, 60 (1) 1951, p. 39–42, and M. Heller, *Doświadczenie Granic*, [in:] *Granice nauki*, ed. M. Heller, J. Mączka, J. Urbaniec, OBI-Biblos, Kraków -Tarnów 1997, p. 7.

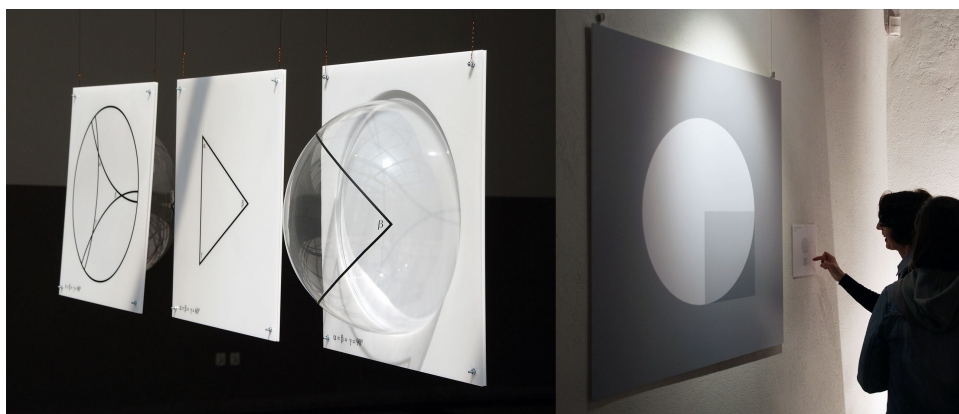
15 J. Jernajczyk, B. Skowron, *Circle and sphere – geometrical speculations in philosophy*, [in:] *Mathematical Transgressions 2015*, ed. P. Błaszczak, B. Pieronkiewicz, Universitas, Kraków 2018, p. 373-389.

16 This project was carried out on a grant from the budget of the Minister of Culture and National Heritage.



mirror we can look deeper into ourselves. This is where the transcendental character of Ludwig Wittgenstein's ethics are sounded: the *inexpressible is inexpressibly included in the expressed*.<sup>17</sup>

In 2011 I created two art projects inspired by mathematical topics. *The Portrait of Pi*, as the title suggests, is a visual representation of the number Pi. It is not however a symbolic representation like the Greek letter  $\pi$ , but a geometrical structure in which the mathematical core of this particular irrational number was really included within it.<sup>18</sup>



04. 90-60-90 (2011), *The Portrait of Pi* (2011)

On the other hand, the installation *90-60-90* discusses the problem of non-Euclidean geometry in which on the contrary to the commonly known Euclidean geometry, there are equilateral triangles of angles other than 60 degrees. Not going into theoretical details here, I would like to emphasize the double meaning of the project's title. Although "90-60-90" is fully justified by its mathematical context, it also brings to mind the pop-cultural ideal measurements of a female body. That approach helps soften the serious tone of the scientific deliberations and introduces a touch of humor. Thanks to that the complicated message can reach a wider group of recipients. I will get back to that theme in the next chapter, because it also plays a vital role in the works comprising the *MathArt* cycle.

The last two installations I would like to describe here were created as part of my PhD project *Spaces of Discrete Motion*. In this interactive installation called *Hypocycloid* (2013), a white dot which moves with returns along a section is visible on a black screen. Touching the screen discloses the true nature of that movement. It turns out that the dot is on the perimeter of the circle which revolves inside a circle with twice as big a diameter. Therefore, the circular movement is directly translated into a linear movement which is contrary to our common intuition. It is worth noting that the analysis of that particular case of hypocycloid played a crucial role in the history of science.<sup>19</sup>

The installation *The Limits of Movement* pertains to the limitations of our visual perception. The digital application generated in real time, presents three points moving along circles. Looking directly, we only see the movement of the point in the middle. The remaining two movements turn out to be too slow or too quick for our visual apparatus.

17 Comp. B. Wolniewicz, *O traktacie* [in:] L. Wittgenstein, *Tractatus logico-philosophicus*, trans. B. Wolniewicz, PWN, Warszawa, 2000, s. XXXVI.

18 The sense of this representation was detailed [in:] J. Jernajczyk, *Irrational images – the visualization of abstract mathematical terms*, „MATHEMATICA APPLICANDA” Vol 43, No 2 (2015), p. 269-279.

19 See J. Jernajczyk, *Thinking in Images: The Role of Digital Media in Popularizing Science*, [in:] *Visual Thinking – Visual Culture – Visual Pedagogy*, ed. H. Rarot, M. Śniadkowski, Politechnika Lubelska, Lublin 2014, p. 36.



05. *Hypocycloid* (2013), *The Limits of Movement* (2013)

The two installations were presented in many art exhibitions. They were also the basis for scientific texts, conference presentations and academic and popularizing lectures, the topics of which were the possibilities and limitations of human cognition.

These complex functions – artistic and cognitive – I also give to my projects which are a part of the multimedia cycle *MathArt*.

## II. MATHART – description of the habilitation project

As a project aspiring to fulfill the conditions of habilitation process in art, I chose the cycle of multimedia installations *MathArt*. The works that are included in that cycle are connected by both the network of references to mathematics, and the similar formal solutions – they are looped moving geometrical images, presented on large format screens.

This cluster of words “math” and “art” I used for the first time in the title of my exhibition which accompanied the 2nd Interdisciplinary Science Conference MATHEMATICAL TRANSGRESSIONS that took place at the KEN Pedagogical University in Cracow in March 2015. Since then I have been using the term “MathArt” to refer to that part of my work, which, drawing inspirations from mathematics, is expressed in the form of artistic creation with cognitive properties.

The relationship between art and mathematics is an extensive chapter in the history of our culture.<sup>20</sup> You can point to many momentous moments in which these disciplines had a reciprocal impact on one another which led to development both in the field of art and in the field of the queen of sciences. Today, however, the predominating majority of artists who refer to mathematics in their art, similar to most of the representatives of the *art&science* stream, most of all rely strongly on purely artistic effects. I give my art projects a little different task, which I have emphasized in the previous chapter – I operate under the assumption that there will be a mutual effect between the scientific and the artistic element; I want my projects, which start with mathematical problems, to intrigue and tempt the recipients by their aesthetic form but what I wish to follow that interest, is the ability to understand the theoretical problem.

Making that idea happen has the biggest chances of success in the media arts domain, because it is characterized by the highest level of flexibility in selecting formal means that are adequate to describe the topics. In particular, the biggest role is played here by digital media which thanks to its discrete structure, and what is linked to that – the programmability,<sup>21</sup> are currently the most effective tool to present and disseminate complex content. Digital media also enable showing what used to be only within our imagination.<sup>22</sup>

The multimedia installations which comprise the *MathArt* cycle are looped moving images, which in the exhibition space are displayed like canvases hung on the walls, they intrigue the audiences with their shapes, colors, movement and in some cases also with subtle sound. Formally, similar to most of my previous projects, they are characterized by geometrical minimalism which fully corresponds to the abstract character of the problems they refer to. In my opinion the inexhaustibility of the aesthetics of geometrical shapes, which is based in the cannon of harmony, symmetry and proportion, known already in antiquity, corresponds here with the overarching cognitive approach. That approach puts the clarity of message taken from science in the forefront, which facilitates different takes, descriptions and representations of complicated issues in a possibly simple way.

The installations do not refer to concrete objects, but to abstract possibly objective and universal reasoning. Thus they are visual metaphors<sup>23</sup> which, in a creative way, connect areas which

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20 See L. Gamwell, *Mathematics and Art: A Cultural History*, Princeton University Press, Princeton, Oxford 2015.

21 L. Manovich, *The Language of New Media*, MIT Press, Cambridge 2001, p. 27, 52.

22 Comp. L. Wiesing, *Sztuczna obecność. Studia z filozofii obrazu*, trans. K. Krzemieniowa, Oficyna Naukowa, Warszawa 2012, p. 137.

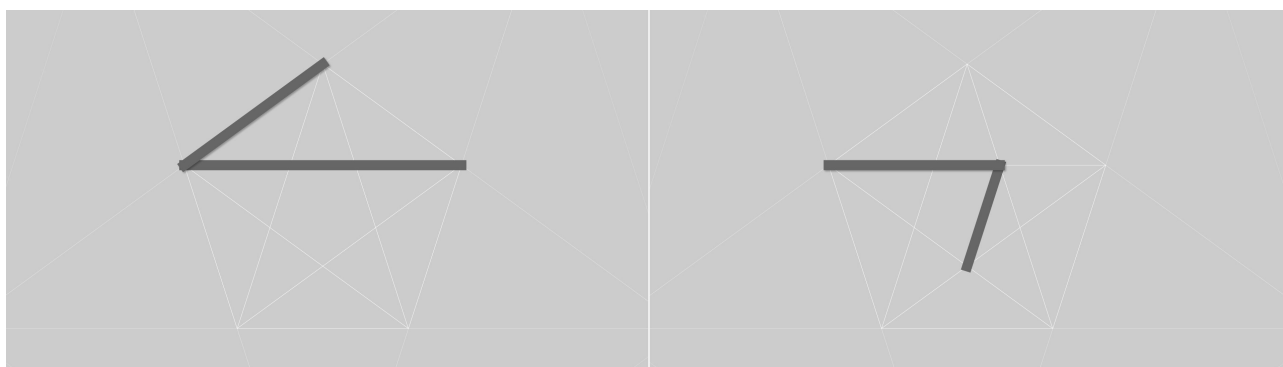
23 A metaphor here is understood as capturing some aspects of a given term in terms relevant to other term (see G. Lakoff, M. Johnson, *Metaphors We Live By*, The University of Chicago Press, Chicago 1980, p. 10) or as transferring meanings from one area to another (see A. Friedberg, *The Virtual Window: From Alberti to Microsoft*, MIT Press,

are seemingly impossible to be related<sup>24</sup> and almost instantly they visualize what in a verbal description would require extensive and complicated description. At the same time, through their polysemy and open form they draw the audiences' attention.<sup>25</sup> By leaving a portion of the topic understated, they open up a wide choice for interpretation; they make the audience desire to discover what a particular image might mean, what it talks about and what it presents.

The *MathArt* cycle consists of six multimedia installations which were created between 2014 and 2016. Descriptions and video and photographic documentations of these projects can be found on [www.grapik.pl/grapik-pl/prace-artystyczne/](http://www.grapik.pl/grapik-pl/prace-artystyczne/)

### ***The Remainder* (2014)**

The installation *The Remainder* was created for the exhibition *What is left* (*To, co zbyło / To, co zostało*) which took place in Prague in 2014 as part of the "Halo Wrocław!" project. I was asked by the exhibition's organizers to approach the title problem from a scientific point of view. I decided to show the problem of irrationality in a creative way. I referred to the antique Euclidean algorithm known from school which allows us to find the largest common divisor of two numbers. For rational numbers that algorithm has to end with a correct result, whereas for irrational numbers it will never end: in the subsequent steps there will always be some nonzero remainder left ("what is left").



06. *The Remainder* (2014), [www.grapik.pl/grapik-pl/prace-artystyczne/reszta/](http://www.grapik.pl/grapik-pl/prace-artystyczne/reszta/)

In order to visualize that process I used a regular pentagon – the figure which since antiquity has been known to have its sides and diagonals in an irrational ratio.<sup>26</sup> That ratio is the famous golden proportion, known as one of the classic and probably mostly called up proofs for the relationship of art and mathematics. The animation presented on the screen shows a consistent division of the sections. At some point however, we end up at the starting point. From the cross-section of diagonals of a regular pentagon, another pentagon is created which inherits the same irrational

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Cambridge 2006, p. 14).

24 Comp. G. Boehm, *Powrót obrazów*, trans. M. Łukasiewicz, [in:] *ibid*, *O obrazach i widzeniu. Antologia tekstów*, UNIVERSITAS, Kraków 2014, p. 280.

25 Comp. *ibid* p. 294.

26 Currently it is assumed that irrational numbers were discovered in 5th century BC by Hippasos from Metapont, who examined the relationship of the sides and diagonals of a regular pentagon (see I.N. Bronsztejn, K.A. Siemiendajew, G. Musiol, H. Mühlig, *Nowoczesne kompendium matematyki*, PWN, Warsaw 2012, p. 5, 149).

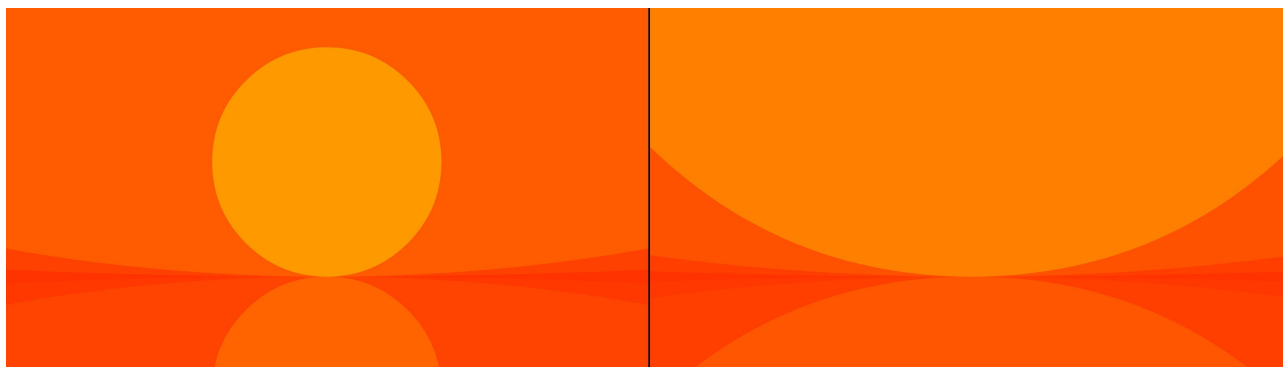
proportions. The process of division then starts from the beginning and never ends. The minimalist, monochromatic animation with the dividing sections is accompanied by the sounds of cracking which stand out from the monotonous whisper of the wind in the background. Owing to this trick, the highly abstract form becomes more tangible and closer to the audience.

In *The Remainder* installation I managed to capture the necessary relationship of irrationality with infinity – an issue that everybody practically knows of but not many fully understand it. A visual representation of that relationship has enabled me to make it much more approachable and intuitive. The cognitive aspect of that fact I described in the article *Irrational images – the visualization of abstract mathematical terms*, published in the specialist magazine MATHEMATICA APPLICANDA.

This project was presented in six exhibitions in Poland and abroad: *What is left (To, co zbyło / To, co zostało)* (Trafacka Gallery, Prague, The Czech Republic, 2014), *MathArt* (KEN Pedagogy University, Cracow, 2015), *Limits 2015 (Granice 2015)* (KINO Gallery, Wrocław, 2015), *MathArt PSN* (Oratorium Marianum, Wrocław, 2016), *MATRIX* (University of Leeds, Great Britain, 2016), *A PICTURE SET IN MOTION (OBRAZ PORUSZONY)* (DoubleTree by Hilton, Wrocław, 2017). Moreover, I often talk about it at conferences, didactic and popularizing lectures.

### The Limits of a Circle (2015)

The inspiration to create this project was the work by Nicolas of Cusa's *On Learned Ignorance* (1401-1464) – a scholar from the end of the Middle Ages; a philosopher, theologian and a mathematician. Cusanus, while contemplating the nature of basic geometrical shapes, noticed that the arc of a growing circle gradually approximates a straight line. That's why the perimeter of an indefinite circle should be equal with a straight line: "... the circumference of the maximum circle, which cannot be greater, is minimally curved and therefore maximally straight."<sup>27</sup> Although the conclusion contradicts our basic intuition, in reality it is an anticipation of discoveries related to non-Euclidean geometries that came much later.



07. *The Limits of a Circle* (2015), [www.grapik.pl/grapik-pl/prace-artystyczne/granice-kola/](http://www.grapik.pl/grapik-pl/prace-artystyczne/granice-kola/)

What in the 15<sup>th</sup> century Cusanus could only have imagined, today we are easily able to present in the form of a moving picture. A looped animation showing indefinitely growing subsequent circles, the arches of which constantly tend to a straight line. Falling yellow circles may bring to mind an

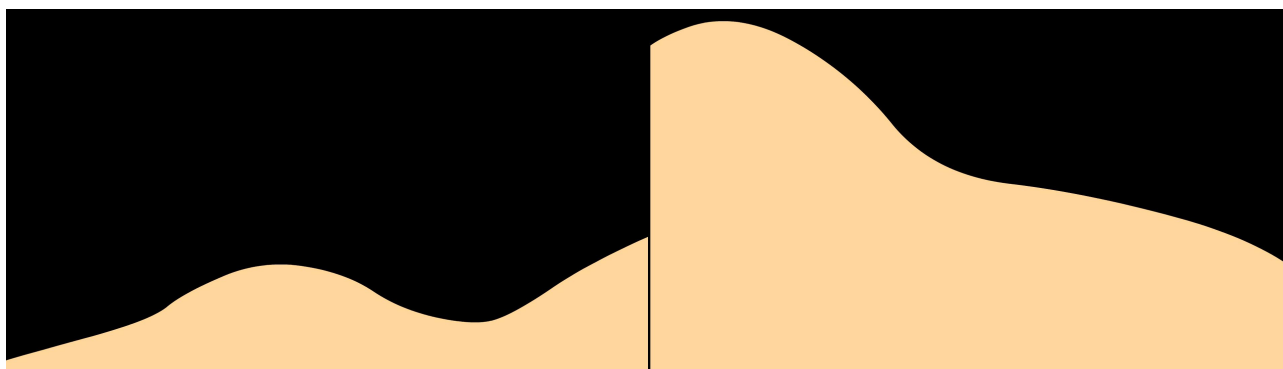
27 Nicholas of Cusa, *On Learned Ignorance*, trans. J. Hopkins, The Arthur J. Banning Press, Minneapolis 1985, p. 21.

image of the setting sun which is reflected in the mirror of water. It is not a coincidental association because many abstract terms and geometrical intuitions have their primary source in observing nature.<sup>28</sup> When the subsequent circles appear, it is accompanied by the piercing sound of a triangle.

I've presented *The Limits of a Circle* installation at seven exhibitions: *Michał Jędrzejewski and pretexts of space (Michał Jędrzejewski i preteksty przestrzeni)* (Test Gallery, Warsaw, 2015), *Limits 2015 (Granice 2015)* (KINO Gallery, Wrocław, 2015), *MathArt PSN* (Oratorium Marianum, Wrocław, 2016), *MathArt around Vinci (MathArt koło Vinci)* (Vinci Fit Art, Wrocław, 2016); *MATRIX* (University of Leeds, Great Britain, 2016), *Young artists in museums. THE HIGHEST LEVEL (Młodzi w Muzeum. POZIOM NAJWYŻSZY)* (National Museum of Wrocław, 2016), *A PICTURE SET IN MOTION (OBRAZ PORUSZONY)* (DoubleTree by Hilton, Wrocław, 2017). This project also provides an illustration of my contemplations included in the article I've referred to before *Circle and sphere – geometrical speculations in philosophy*.

### Definite Integral Figures (2015)

The installation *Definite Integral Figures (Ciałka oznaczone)* was created with the *Limits 2015 (Granice 2015)* exhibition in mind at which I also presented the previously described projects *The Remainder* and *Limits of a Circle*. The screen shows the outline of a moving female body – figure. That shape becomes precise in static moments and in movement it loses its clarity. The sound effect is gentle breathing.

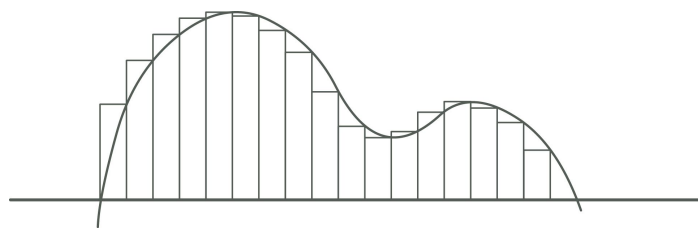


08. *Definite Integral Figures* (2015), [www.grapik.pl/grapik-pl/prace-artystyczne/cialka-oznaczone/](http://www.grapik.pl/grapik-pl/prace-artystyczne/cialka-oznaczone/)

The source of inspiration for this project was the *definite integral* which in geometrical interpretation corresponds to the area under a curve (under the graph of function) in a set out section. In theory, that area approximates in rectangular "bars", the number of which tends to infinity (in a finite interval), whereas the width of each one of the bars tends to zero.<sup>29</sup> In practice, while measuring a preciseness of some sort has to be decided on beforehand. For example, on the screen, a single bar will never be thinner than the width of a pixel.

28 Comp. P. J. Davis, R. Hersh, *The Mathematical Experience*, Birkhäuser, Boston 1981, p. 126, 158.

29 Comp. I.N. Bronsztejn, K.A. Siemiendajew, G. Musiol, H. Mühligh, *Nowoczesne kompendium matematyki*, trans. A. Szczech, M. Gorzecki, PWN, Warszawa 2012, p. 481.



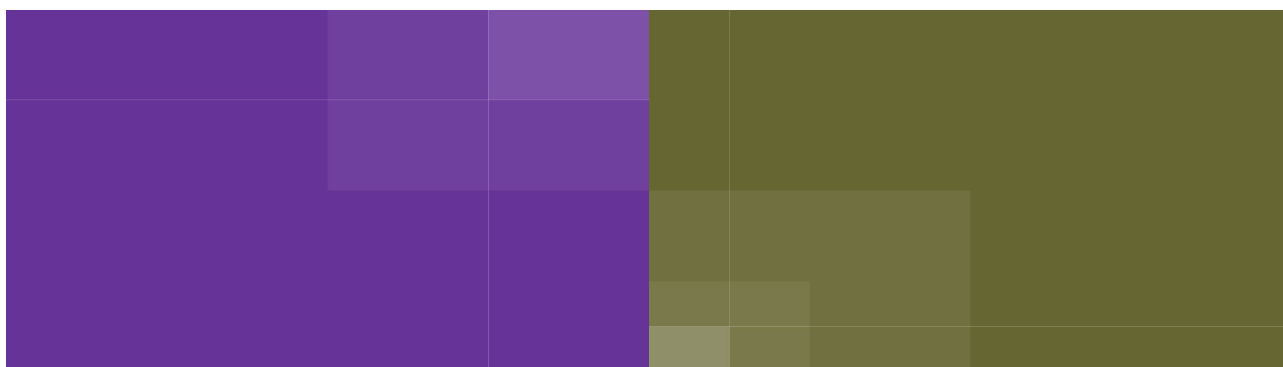
09. definite integral scheme

The installation's title is a play on words between "integrals" (Polish: całka) and "body/figure" (Polish: ciałka). In the Polish version, it allows for letting in a touch of air into this hermetic sphere of scientific speculations and refers to these problems with some distance and humor. At the same time, the element of physicality which is so natural in art, unexpectedly explains content which belongs to an entirely different discipline.

The installation *Definite Integral Figures* has been presented in two exhibitions: *Limits 2015 (Granice 2015)* (KINO Gallery, Lower Silesian Film Center, Wrocław, 2015) and *Math Art PSN* (Oratorium Marianum, Wrocław, 2016). It was also described in the *Quickness in culture (Szybkość w kulturze)*.<sup>30</sup>

## Zeno<sup>2</sup> (2015)

This project in its very simple form, was the closing piece of the set of installations presented as part of the *Limits 2015 (Granice 2015)* exhibition. The point of reference was the famous paradox of Zeno of Elea called *dichotomy*. In Ancient Greek mathematics *dichotomy* meant a symmetrical bisection of a section.<sup>31</sup> Zeno was convinced that the world in its nature is unchangeable, he used that construction to prove that movement is impossible and that it's just an illusion of senses. Zeno's reasoning was shown to us in a residual state by Aristotle,<sup>32</sup> and is most often presented in the following form: *to reach the target, first you have to pass half of the distance, then half of the remaining distance, half of the remaining distance... and so on indefinitely; which can't be done in finite time, therefore, movement is impossible.*



10. Zeno<sup>2</sup> (2015), [www.grapik.pl/grapik-pl/prace-artystyczne/zenon/](http://www.grapik.pl/grapik-pl/prace-artystyczne/zenon/)

30 J. Jernajczyk, *Myśl i ruch – poznawcze znaczenie dynamicznych obrazów (wideoesej)*, [in:] *Szybkość w kulturze*, ed. K. Zadros, Wydawnictwo Naukowe UKSW, Warszawa 2016, p. 17-20.

31 See Euclid, *The first six books of the Elements of Euclid*, W. Pickering, London 1847, p. 10.

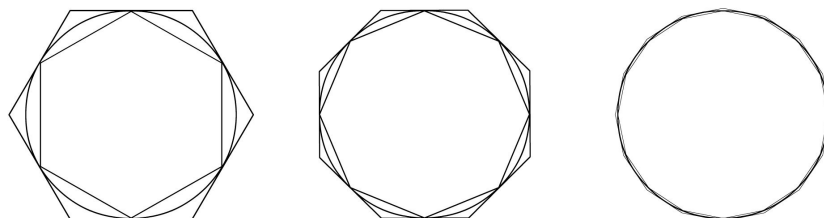
32 Aristotle, *Physica*, trans. R. P. Hardie and R. K. Gaye, [in:] *The Works of Aristotle*, vol. II, ed. W. D. Ross, The Clarendon Press, Oxford 1930, 239 b.



In the installation *Zeno*<sup>2</sup> in line with the suggestion from the exhibition title, I moved the dichotomic bisections of a one-dimensional section into the second dimension, consistently dividing the screen surface. At certain stages of these evolutions, when the subsequent bisections indicate sufficiently small areas, the image becomes augmented and a series of dichotomic bisections starts from the beginning. The sequences that come one after another are accompanied by a change of screen color which is another stimulus and captures the recipients' attention for longer by engaging them in contemplating indefinite divisions of the screen's surface.

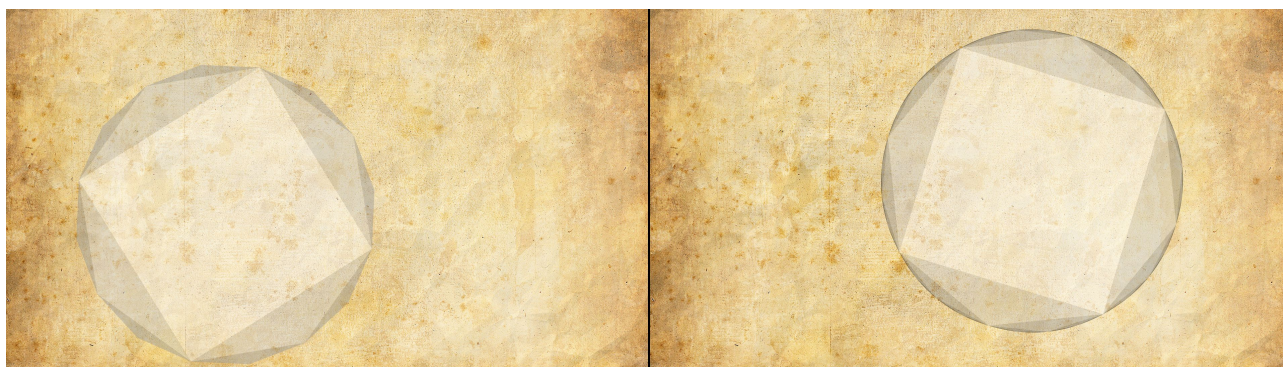
### ***The Exhaustive Picture* (2016)**

This project was created thinking about the individual exhibition *MathArt around Vinci* which both in its content and form, was supposed to refer to the scientific-artistic search of Leonardo da Vinci. The source of inspiration in this case was the ancient Greek *method of exhaustion* with the aid of which they were able to approximate the area of complicated figures including the circle.<sup>33</sup> The method included writing into a circle and circumscribing subsequent regular polygons which along with the increasing number of angles approximated the shape of a circle more and more; however, they were never able to become equal with it.



11. Method of exhaustion scheme

On the screen with its background filled out with the texture of old paper, we observe a freely moving figure. Its first shape is a rectangle which next transforms itself into an octagon, then into a regular hexadecagon (16 angles) and a tricotacydagon (32 angles). At some point we can't distinguish the resulting figure from a circle. However, because a truly geometrical circle is necessarily irrational (related to the irrational number  $\pi$ ), that figure disappears from the screen in a moment like a soap bubble. That is because irrational objects cannot be immortalized in matter.



12. *The Exhaustive Picture* (2016), [www.grapik.pl/grapik-pl/prace-artystyczne/obraz-wyczerpujacy/](http://www.grapik.pl/grapik-pl/prace-artystyczne/obraz-wyczerpujacy/)

33 V.J. Katz, *A History of Mathematics. An Introduction*, Pearson Education, Boston 2009, p. 84.



In the cognitive sense *The Exhaustive Picture* goes beyond the area of mathematics and also refers to epistemological issues. Similar to the project described in the previous chapter *The Circle of Knowledge* (2008), it can be treated as a visual metaphor on the development of human knowledge. We see that concept in Nicolas of Cusa who compared the fullness of truth to an ideal circle, a human tending to the truth to the polygons circumscribed into that circle: "Hence, the intellect, which is not truth, never comprehends truth so precisely that truth cannot be comprehended infinitely more precisely. For the intellect is to truth as [an inscribed] polygon is to [the inscribing] circle. The more angles the inscribed polygon has the more similar it is to the circle. However, even if the number of its angles is increased ad infinitum, the polygon never becomes equal [to the circle] unless it is resolved into an identity with the circle."<sup>34</sup>

I developed the topic of philosophical metaphors which have their source in geometry in the previously quoted paper *Circle and sphere - geometrical speculations in philosophy*.

The installation *The Exhaustive Picture* was presented at two artistic exhibitions: *MathArt around Vinci (MathArt koło Vinci)* (Vinci Fit Art, Wrocław, 2016) and *A PICTURE SET IN MOTION (OBRAZ PORUSZONY)* (DoubleTree by Hilton, Wrocław, 2017). I also referred to it during multiple lectures and conference papers.

### ***Inflection Points and Extrema (2016)***

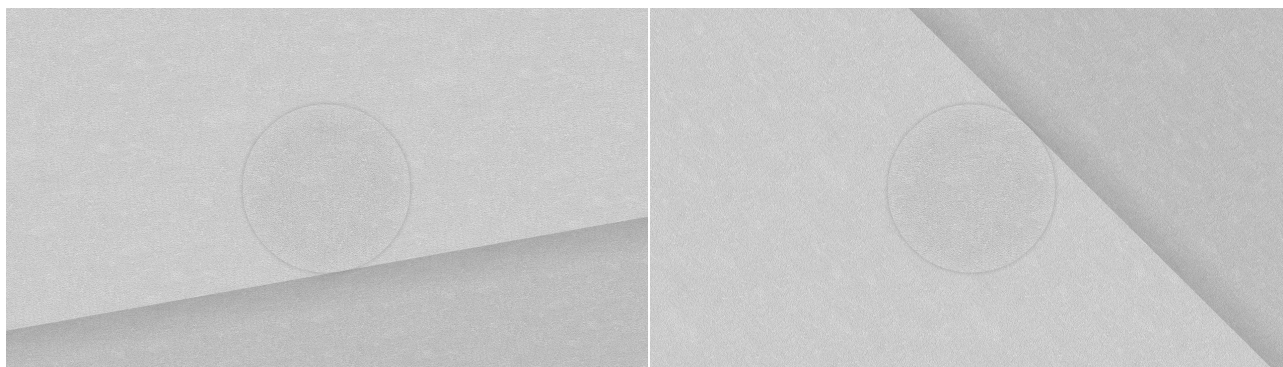
The last project from the cycle *MathArt* is the installation *Inflection Points and Extrema* which was created on the occasion of the exhibition *Solstice (Przesilenie)* – the next part of the cycle "Halo Wrocław!" in 2016 in Budapest. I was once more invited by the organizers to refer my artistic response to the exhibition's title in sciences. Instantly, my thoughts went towards the characteristic points of a mathematical function: the extrema (minima and maxima) and inflection points.



13. The extrema (minima and maxima) and inflection points

As I was trying to present a dynamic image, I decided that the model's curves will correspond to the changes in speed of a rolling circle. In order to give the entire image an intriguing character, I showed this movement not from the perspective of an external observer but from the perspective of a moving object. As a result, in the final picture we see a centrally located circle with the surrounding twirling around it.

34 Nicholas of Cusa, *On Learned Ignorance*, trans. J. Hopkins, The Arthur J. Banning Press, Minneapolis 1985, p. 8.



14. *Inflection Points and Extrema* (2016), [www.grapik.pl/grapik-pl/prace-artystyczne/ekstrema/](http://www.grapik.pl/grapik-pl/prace-artystyczne/ekstrema/)

## Conclusions

The cognitive synergy between art and science which is a characteristic in my art, is fully evinced in the *MathArt* cycle I described. All component multimedia installations refer to mathematical problems and in line with the adopted assumption they are supposed to familiarize the audience with that content and explain it through an image.

There might be a doubt whether the reception of a particular project is not more dependent on the analysis of its theoretical description than on the contemplation of the work itself. My answer is: yes and no. These installations in their purely visual form make up autonomous art objects, which influence the recipient on the aesthetic level. However, if a project attracts the recipients' attention to the point that they want to take a look at the description, then contemplating the description will allow the directing to possible references and interpretations. It can happen on a few different levels. The first level is the title of the project which more or less directly refers to scientific content by which it sets off the recipients' association process. The highlighted part of the description provides an initial and simplified explanation of these associations. For the more inquisitive viewers some more detailed explanations and extended descriptions are provided. However, neither scraping through the descriptions nor fully understanding them is a necessary condition to interpret these works. They can only direct that interpretation and potentially deepen it.

Concluding this chapter I will also refer to one more issue which has come up with reference to some of the projects described here but I think it requires a comprehensive discussion in the context of the whole *Math Art* cycle, or even in the wider context of my approach to creating art works which are associated with scientific problems. Namely, getting some sort of distance, a possibility to let some air into scientific speculations or even introducing humorous elements. Science usually can't afford to take such a free approach, whereas in art it is very welcome or even natural. To obtain that I most often use a polysemy of words and plays on words. In the cycle *MathArt* you can see that in the installation *Definite Integral Figures*, *The Exhaustive Picture*, *Zeno<sup>2</sup>*, *Inflection Points and Extrema*. What is the sense and aim in using such procedures? They are supposed to additionally surprise the audience and captivate their attention so that they can be pulled into the abyss of visual reflections. I try not to abuse those measures. They can't distort the sense of the content to which the projects refer, because that would be undermining fundamental principles of my art. It's vital to maintain the right proportions between the aesthetic, cognitive and humorous elements.

### III. COGNITIVE ROLE OF AN IMAGE – research work

My art activities are closely tied to my scientific endeavors for which the natural foundation is the cognitive synergy that takes place between science and art. Amongst many of my theoretical interests which pertain to images or in the wider sense – the imaging, the first plane is taken up by two topic areas: 1) the cognitive role of an image, perception and visual imagination, and 2) the discrete structure of a moving image. I will start with discussing the first area because the *MathArt* cycle, the main subject of this paper, is directly related to that.

#### Visualization of scientific problems

As one of my most prominent scientific achievements I regard the interdisciplinary project *A visualization of scientific issues – classic examples in new digital media*. The project was done between 2014-2016 as part of research grant from the Foundation for Polish Science which was awarded in the Poland-wide contest INTER (SKILLS program). It is worth mentioning that I was the only representative of humanist sciences awarded in 2014 and at the same time the only shortlisted and awarded representative from the art world in the entire five-year history of that prestigious competition.

The core of the project *A visualization of scientific issues – classic examples in new digital media* was researching the cognitive properties of an image with the particular focus on the role which a moving and programmable digital image plays in approximating scientific issues. Chosen problems from the history of science and philosophy were analyzed in discovering or explaining of which the image played an essential role. Many of these problems also assumed a dynamic aspect in the description – change, or transformation, which could have been fully considered only in the era of the moving picture.

The project was carried out in two mutually influencing and supplementing planes: scientific and artistic. The factor bonding these two areas was *visual thinking*. According to German psychologist and art theorist Rudolf Arnheim "...productive thinking in any area of cognition is perceptual thinking."<sup>35</sup> In practicing these competencies art plays a significant role because it is "...the most powerful means of strengthening the perceptual component without which productive thinking is impossible in any field of endeavor."<sup>36</sup> Simultaneously art goes beyond its own field and becomes a significant cognitive factor also in the sciences.

The project was the responsibility of an interdisciplinary research team which apart from myself included: Marcin Czub, Ph.D. – psychologist from the University of Wrocław, Justyna Głowala, Ph.D. – a philosopher from the University of Wrocław, Bartłomiej Skowron, Ph.D. – a philosopher from the Warsaw University of Technology and Dermot Wilson – a visual artist from Canada.

During the work on the *A visualization of scientific issues...* project I prepared and delivered five papers at science conferences and seminars and seven popularizing lectures for middle-school students and older. Along with M. Czub, Ph.D., I prepared a method of comparing perception and the level of understanding scientific content presented with the use of static and moving images. We carried out pilot tests to ensure that the method was sound. As part of that project I also created three out of six installations included in the *MathArt* habilitation cycle: *The Limits of a Circle*, *Definite Integral Figures* and *Zeno*<sup>2</sup> and I organized five art exhibitions. Two exhibitions by Dermot

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35 R. Arnheim, *Visual Thinking*, University of California Press, Berkeley, Los Angeles, London, 2004, p. 296.

36 Ibid, p. 3.

Wilson: *Iterate: Notches and Spirals Derived from the Pseudo-circle* (Wrocław, 2015) and *Emanate: Videos and Drawings* (Wrocław, 2015) and three of my own exhibitions: *MathArt* (Cracow, 2015), *Limits 2015 (Granice 2015)* (Wrocław) and *MathArt PSN* (Wrocław, 2016). An important element in delivering the project *A visualization of scientific issues...* are the following science publications:

- J. Jernajczyk, *Irrational images – the visualization of abstract mathematical terms*, „MATHEMATICA APPLICANDA” Vol 43, No 2 (2015);
- J. Jernajczyk, B. Skowron, *Circle and sphere – geometrical speculations in philosophy*, [in:] *Mathematical Transgressions 2015*, red. P. Błaszczak, B. Pieronkiewicz, Cracow, 2018.

In the first of these texts, focused on the possibilities of presenting irrational numbers, amongst other topics, I describe the cognitive aspect of *The Remainder* installation (2015) included in the *MathArt* cycle. The second text written together with Bartłomiej Skowron, Ph.D. pertains to philosophical visual metaphors (ontological and epistemological) based on the geometrical properties of the circle and sphere. The grounds for the theoretical deliberations were the art projects *The Circle of Knowledge* (2008) and *The Limits of a Circle* (2015). The relationship of the geometrical *method of exhaustion* and the visual metaphor of the human pursuit of knowledge analyzed here and described by Nicolas of Cusa were the direct impulses that led me to create the installation *The Exhaustive Picture* (2016).

The cognitive role of images is also the subject of three other scientific papers which were written independently of the project described above:

- J. Jernajczyk, *Portraits of the Chance (Portrety przypadku)*, „Racjonalia. Z punktu widzenia humanistyki” nr 3 2013;
- J. Jernajczyk, *Thinking in Images: The Role of Digital Media in Popularizing Science*, [in:] *Visual Thinking – Visual Culture – Visual Pedagogy*, ed. H. Rarot, M. Śniadkowski, Politechnika Lubelska, Lublin 2014;
- J. Jernajczyk, *Thought and motion – cognitive meaning of dynamic images (video-essay) (Myśl i ruch – poznawcze znaczenie dynamicznych obrazów (wideosej))*, [in:] *Quickness in culture (Szybkość w kulturze)*, ed. K. Zadros, Wydawnictwo Naukowe UKSW, Warsaw 2016.

## Spaces of Discrete Motion

The second area of my scientific interests is the structure of the moving picture, its properties and perception. The theoretical part of my doctoral thesis *Spaces of Discrete Motion. The Origin and Characteristics of the Discrete Illusion of Motion* was focused on that issue. The studies I did in that scope touch upon a wide spectrum of problems, including but not limited to: the analysis of the problem of *continuity* and *discreteness* in philosophy, physics and mathematics; philosophical and physical reflections on movement, starting with the ancient paradoxes by Zeno of Elea up until modern-day science; the concept of a discrete structure of the world – ancient and modern atomism and contemporary theories of quantum gravity; the history of evolution of the moving pictures and testing its properties in terms of signal theory; researching discrete aspects of movement perception and conceptual cognition; analysis of discrete information coding systems. I refer to these topics in a few scientific publications in which, to emphasize the discreteness of grounds for all forms of a moving picture, I use my own term of a *discrete illusion of movement*:

- J. Jernajczyk, *Archaeology of discrete illusion of movement (Archeologia dyskretnej iluzji ruchu)*, „Tekstoteka filozoficzna” no. 2 2013;
- J. Jernajczyk, *Lossy representations of excessive reality*, [in:] *Excess & Lack*, ed. Ł. Huculak, B.

Skowron, J. Jernajczyk, K. Dąbrowska, M. Zakrzewska, R. Zarzycki, E. Geppert Academy of Art and Design in Wrocław and the City of Wrocław, 2013;

- J. Jernajczyk, *Movement out of constancy – deliberations on the mechanism of creating a moving picture*, [in:] *A picture set in motion*, ed. W. Gołuch, J. Jernajczyk, Eugeniusz Geppert Academy of Art and Design in Wrocław, Wrocław 2016;
- J. Jernajczyk, *Grains of thought – on properties of discrete forms of representing information* (*Ziarna myśli – o własnościach dyskretnych form reprezentacji informacji*), [in:] *Problemy filozofii matematyki i informatyki*, ed. R. Murawski, J. Woleński, Wydawnictwo Naukowe UAM, Poznań 2018 (accepted for print).

The second to the last of the listed papers was published in the bilingual Media Art Department's monograph *Obraz poruszony / A picture set in motion*, which I co-edited with Professor Wiesław Gołuch.

### Scientific lectures and presentations

After defending my doctoral thesis (December 2013) I delivered twelve papers in Polish and international conferences and five lectures at the invitations of universities and scientific societies. I regard the ones listed below as the most important ones:

- A speech *Thinking in Images: The role of art in education and popularizing science*, at the 3rd Interdisciplinary Scientific Conference Philosophy and Ethics in school. Artistic education – challenges, which took place in March 2014 at the A. Mickiewicz University in Poznań;
- A lecture *The role of art in popularizing mathematics*, at the invitation of the Wrocław Division of the Polish Mathematical Society, April 2014, Mathematical Institute of the University of Wrocław;
- A presentation *Circle – mathematical inspirations in philosophy and art*, at the 2nd Interdisciplinary Scientific Conference MATHEMATICAL TRANSGRESSIONS, which took place in March 2015 at the KEN Pedagogical University in Cracow;
- A presentation *Discrete representations – ontological and epistemological aspects of the discrete structure of static and dynamic digital images*, at the 2nd Poland-wide Interdisciplinary Conference in the cycle: What and how do we cognize through images? "Reality and its representations – from mimetism to constructivism", September 2015 in Kazimierz Dolny;
- A lecture *Visual mathematics – the cognitive role of images in sciences, art and education*, at the invitation of Professor Piotr Błaszczuk, who runs the Didactic, Philosophy and General Mathematics Seminar, December 2015 at the KEN Pedagogical University in Cracow;
- A presentation *Geometric cognitive metaphors – the coexistence of mathematics, philosophy and art*, as part of The MATRIX Conference, September 2016, Leeds University, Great Britain;
- A presentation *Geometrical models of scientific knowledge evolution – at the border of mathematics, philosophy and art*, at the 5th Conference "Philosophy of Mathematics and Computer Science", December 2016, at the Adam Mickiewicz University in Poznań;
- A lecture *Discreteness and continuity. Philosophical aspects of digital representation of movement*, at the invitation of Professor Witold Marciszewski and Paweł Stacewicz, Ph.D. who run the PHILOSOPHY OF SCIENCE seminar, February 2017, Warsaw University of Technology;
- A lecture *Observed and imagined – on visual roots of our cognition*, October 2017, Contemporary Museum in Wrocław.

## Awards and memberships

An important moment in my scientific-artistic development was joining the Academy of Young Scholars and Artists, the first institution of this kind in Poland (<http://akademia.wroc.pl>). I was honored to have become one of the first twelve members of the Academy who were chosen in 2010 by the Honorary Jury including: Professor Andrzej Białas – The President of the Polish Academy of Skills, Professor Marek Bojarski – the then Rector of the University of Wrocław, Rafał Dutkiewicz, PhD – the Mayor of Wrocław, Professor Michał Kleiber – the then President of the Polish Academy of Sciences, Professor Tadeusz Luty – Honorary President of the Conference of Academic Rectors of Polish Universities, Professor Maciej Żylicz – the President of the Foundation for Polish Science. Being part of the Academy has given me the possibility to exchange my thoughts freely with renowned specialists representing different fields of sciences and art, which significantly widened my cognitive horizons. As part of the Academy activities I co-created and participated in a few novel interdisciplinary research and education projects, such as *Excess and lack*, *Filomates*, *The language of machines* and *Math doesn't bite*.

An important event was when I was awarded with the Minister of Science and Higher Education scholarship for outstanding young scholars. Being in a group of 150 young scholars who were chosen from all over Poland and who represent all science areas was for me a validation of my choice to follow the path with a scientific-artistic character. Owing to that support I was able to become engaged in innovative and experimental research projects which were often loaded with a significant risk of successful implementation. Most of all, however, I was able to stay faithful to the interdisciplinary research stand that I had taken, without having to submit to the dominating trends in art and sciences.

## IV. THINKING IN IMAGES – didactics and education

The art projects I create are not only inspired by scientific problems but as I've mentioned before they are supposed to familiarize the audience with them and explain them. My research interests concentrate around cognitive properties of images and art which uses images. It is not surprising then that my art work and scientific work naturally translate to educational and didactic activity which is the third – though not least important – pillar of my professional activity.

This work is accompanied by the conviction that with images you can explain many problems which according to common opinion are regarded as complicated. An excellent example here is the definite integral which is the main problem of the lecture *Can you build every figure out of triangles?* prepared for students of the Children's University aged 8 and 9. Multiple questions and comments of the young students clearly showed a very high level of understanding of advanced content which were presented to them purely visually. On the other hand, proof that this form of explaining problems was very attractive to them, was the fact that I was awarded a special mention by the children in the Children's University – Lecturer of the Year competition.

My positive attitude towards visual education is not completely uncritical. I'm conscious of the fact that not all science issues can be visualized sensibly and effectively. The attempts to visualize "by force" problems that are too advanced and complex may lead to unqualified simplifications and can create the opposite effect of what was expected – instead of explaining something they could mislead. A teacher or a person popularizing science who uses visual tools has to remember that there's certain content you can explain with an image, and not more.

### Educational and science popularizing projects

Before I describe my didactic work at the Eugeniusz Geppert Academy of Art and Design in Wrocław, I will present a few educational and polarization projects which were targeted at children, youth and adults. I decided to do it in this order because the content which was worked out during these projects, similar to the content which was produced as part of the artistic and scientific work, largely contributed to the program and formula of my classes.

In 2014-2016 with the support of the grant I received from the Foundation for Polish Science (a prize in the national competition eNgage [SKILLS program]) I started a popularizing science-art project *Philosophical Zoo*. The core of that project is popularizing philosophy, whereas the key to choosing problems are animals which appear in the writings of famous philosophers. These approachable, popular science style descriptions of the particular issues, are accompanied by my own illustrations which act as a graphical and usually satirical commentary. During the grant program I prepared the content and drawings for 26 problems (philosophical animals), I also prepared 9 public talks, I designed a logo and started an internet website [www.filozoficznezoo.pl](http://www.filozoficznezoo.pl). The project was received with enthusiasm both in the school environment (amongst students and teachers) and academic circles. Teachers and popularizers of philosophy refer to the examples of philosophical animals during school lessons and educational events. The project *Philosophical Zoo* is still developing and articles presenting subsequent problems are published regularly in the Poland-wide magazine *Filozofuj!*. Between October and November 2017 some of the graphic sketches were presented at the exhibition *Philosophical Zoo* in the street gallery Szewska Pasja in Wrocław.

A project with a wider spectrum of influence is *The Language of Machines* which introduces teaching programming starting as early as the first grade of elementary school. Since 2013 that project has been implemented annually in more than 50 schools in Wrocław and the number of students participating in it has gone over 3000. The teaching program of *The Language of machines* was created on my initiative at the Academy of Young Scholars and Artists (the co-creators are J. Drapała, Ph.D. and Bartłomiej Skowron, Ph.D.), whereas the implementation is carried out by the City departments: The Department of Education, The Office for Cooperation with Higher Education Schools and the Wrocław Center of Professional Teachers' Education. The first part of *The Language of Machines* focuses on teaching basic terms and programming skills based on visual intuition, without referring to abstract code. I prepared *Graphical Programming Language* which aids in teaching that. It allows for carrying over content pertaining to fundamental logic rules with the use of a visual code, which has its source in art. Teaching *The Language of Machines* is supported by the *KoLo* and *KoLes* computer applications that I designed. After four years of functioning as an extra subject (nonmandatory) since 2017 *The Language of Machines* will be a part of the new program at the level of early school education and computer education. I have been continuously participating in the work related to further development and promotion of this project.

Apart from the abovementioned two projects I've also been engaged in other initiatives of an educational and popularizing character, to name a few The Lower Silesian Festival of Science (2016), *Filomates* (2016), the Children's University (2016), Mathematics Week at the VII high-school in Wrocław (2015-2017), *Math doesn't bite* (2014-2015), the Wrocław Philosophical Education Society (2014-2015). All together in the years 2013-2017 I gave over 25 educational and popularizing lectures directed mainly at children and school youth.

## Didactic work

As part of my job as an assistant professor at the Faculty of Graphic Arts and Media Art at the Eugeniusz Geppert Academy of Art and Design in Wrocław, I run didactic classes. The curriculum of my classes are largely inspired by my artistic, scientific and educational work.

As the most original and unique I would single out the subject *Elements of sciences in art* which I've been running since 2008 for the first-year undergraduate students in the Media Art Department. In the course the students become familiar with chosen terms from the area of sciences (mathematics, logic, informatics and physics) and philosophy – that knowledge is either recommended or necessary for the conscious and fluent usage of digital media in the creative process. On the one hand I accentuate the influence science has on art, and on the other, the role art can play in scientific cognition and during the presentation and popularization of knowledge. Complicated content is presented in a relatively accessible way – with the use of images, without abstract formulas or hermetic terminology. In order to pass the subject, the students prepare multimedia projects of artistic character in which they refer to chosen science problems. The program of that subject utilizes my projects, results and papers which were created during science-art research projects (*Spaces of Discrete Motion*, *Visualization of scientific issues...*, *Philosophical Zoo*) and, as well, uses experience gained during educational and popularization lectures.

The subject *Methodology in research work* for first-year students of the Interdisciplinary Doctoral Studies at the Academy of Art and Design refers to similar topics. I created the program for that subject together with Bartłomiej Skowron, Ph.D. and since 2013 we have been running these classes together. Since 2017 I have run it myself and Skowron appears as a guest lecturer.



During the classes, in the context of creative, research and didactic work of the students, we emphasize the role of visual intuition in common and scientific cognition. Theoretical reflection over creative work is done from the perspective of general academic methodology. The students also practice self-presentation techniques and formulating optimal visual messages. The program of these classes also uses the outcomes of my research projects (scientific and artistic ones) and educational and popularization undertakings.

Another, but not less significant area of my didactic work, focuses around the topics related to programming and designing interactive installations. The main subject for which I continuously try to perfect the optimum teaching program is *Multimedia programming* which I run for the first-year post-graduate students at the Media Art Department. The aim of that subject is to widen the creative workshop of students by the skill of consciously designing algorithms, self-sufficient coding in a chosen programming environment and creating screen applications and interactive installations. In the classes the students learn basic programming intuitions essential for using various programming languages. At the same time, they work in concrete programming environments which allows for the efficient programming of multimedia content. The students also design their own interactive installations in which they can use the practical programming knowledge in art projects. At the beginning phase of the *Multimedia programming* classes I use the materials and tools that were prepared for *The Language of Machines*.

A similar program but in a slightly narrower sense, I also use in the *Interactive actions* subject and during the subject *Interactive video* which I co-run with Professor Maja Wolińska (for the first-year distant learning post-graduate students *Photography and multimedia*).

Students' projects which are created as part of *Elements of sciences in art*, *Multimedia programming*, *Interactive actions* and *Interactive video*, have been presented at multiple exhibitions in Poland and abroad showing the oeuvre of the Media Art Department and the Faculty of Graphic Arts and Media Art.

Apart from the subjects described above, as part of the Media Persuasion Studio run by Professor Wiesław Gołuch I also co-run the subjects: *Media persuasion* (Media Art) *Intermedia* *Graphic Arts* (Graphic arts and Graphic designing), *Multimedia* (Photography and Multimedia). The students that I independently or cooperatively took care of have won a few prizes and special mentions at the local and Poland-wide art and designing competitions. I was also a reviewer of nineteen text-based Master's theses by Graphic Art and Media Arts students from the stationary and distance learning programs.

In 2006-2012 I run classes in the scope of *theory of signals* and *multimedia programming* for the mathematics students at the Faculty of Mathematics and Computer Science at the University of Wrocław.

In September 2017 I received a prize for individual didactic achievements by the National Culture and National Heritage Minister.

## V. CONNECTING WROCŁAW – organizing and popularizing work

Working in the artistic and scientific environments at the same time I have a unique possibility to pursue the right position of art in a world dominated by science; to pursue its fuller acceptance and appreciation as an independent and irreplaceable cognitive discipline. Because art as argued by Nelson Goodman "...must be taken no less seriously than the sciences as modes of discovery, creation, and enlargement of knowledge in the broad sense of advancement of the understanding..."<sup>37</sup> That role is particularly essential in the current situation when scientific and art degrees and titles are equaled, and art work is evaluated on the rules analogous to the ones for science. I am not arguing the correctness of this solution here but I would like to present examples of my organizing activities in the context of the relationship between art and science.

The main field of execution for the aforementioned goals is my work in the Academy of Young Scholars and Artists. It was out my initiative, and some other members, that the Student Scholarship Program of the City of Wrocław which in the past gave grants only to PhD students of mathematics, information technology, physics, chemistry, biology and medicine, was extended in 2013 to two more categories: the Wincent Styś scholarship for students of social studies and humanist subjects and the Jerzy Grotowski scholarship for art students. Since that moment, I am annually a member of the committee jury which recommends candidates for art scholarships; some years I was also a part of the humanist, mathematics and interdisciplinary committees.

In February 2013 I represented the Academy of Young Scholars and Artists during the international seminar "Learning Institutions for a Community of Learners" popularizing the results of a OECD review pertaining to the role of a university education in the development of Wrocław. In my presentation I focused on art studies graduates in the context of the local, national and world job market.

During the conference for the 5<sup>th</sup> year of the Academy of Young Scholars and Artists, which took place on 12 November 2015 in the Session Hall of the Wrocław City Council, I participated in the debate "The meaning and future of the academes of young scholars." My voice in the debate pertained to the diagnosis of a deep clash between science and humanist topics and the search for a solution to mitigate those often unjustified divisions.

On behalf of the Academy I co-organized science-art project "Excess and lack" in 2013. As part of that project we organized a visit of Professor Michał Heller in Wrocław, a series of popular science lectures were delivered by the Academy members, a Poland-wide interdisciplinary "Excess and lack" conference was organized and was accompanied by an exhibition of the same title. Finally, we published a bilingual scientific-artistic publication *Excess and Lack* which I co-edited.

In September 2013 along with Professor Łukasz Huculak I organized an exhibition by the members of the Academy entitled *Areas under Curves* which accompanied the international conference Academia Europea "25th Anniversary Conference. European science and scholarship looking ahead – challenges of the next." It is worth mentioning here that since 2016 the Academy of Young Scholars and Artists is affiliated with Academia Europea – the largest and most prestigious European scientific society.

In my alma mater, apart from the teaching and creative work, I naturally take care of a series of organizational tasks related to my post as an adjunct (participation in diploma-awarding and examination committees, organization of students' and staff's art exhibitions, coordination of diplomas, preparation of entry exams tasks, etc.). Since 2014 I have been a member of the Faculty of Graphic Art and Media Art Council. The Academy's and Department's authorities entrust me with

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37 N. Goodman, *Ways of Worldmaking*, Hackett Publishing Company, Indianapolis 1978, p. 102.

many functions which require a responsible approach. In 2016 the Rector of the Academy of Art and Design in Wrocław nominated me to the Senate Committee for Artistic Research, Science, Publishing and International Cooperation. Since 2016 I have been the president of the Cancellation Committee for Interdisciplinary Doctoral Studies Scholarships (in 2015 I was a vice president thereof). The dean of the Faculty of Graphic Arts and Media Art appointed me in 2014 to be a member of the Faculty's Committee for financial grants for young scholars and PhD students and in 2015 to the Faculty's Committee for confirming the effects of learning.

I was the organizer of the Fists Poland-wide Conference "Concepts and research practice, creation and didactics in media departments of art academies" which took place in March 2016 in the Center for Applied Arts. Center for Innovation of the Academy of Art and Design in Wrocław. I was also a member of the organization committee of the second edition of that conference which took place in May 2017 under the motto "Intermedia and the cinematographic turn."

I have also been engaged in organizing and coordinating the cooperation of my faculty with other universities and cultural and scientific institutions. In 2009-2014 I coordinated the cooperation between the Media Art Department with The National Ossoliński Institute – the Academy staff provided a project and multimedia support for a few exhibitions at the Ossolineum, including the two versions of *The history of the Pan Tadeusz manuscript* (2012 – 2014). In 2015 the cooperation I initiated with the National Forum of Music resulted in two competitions for Faculty of Graphic Arts and Media Art students for an animated NMF logo and a promotional spot for the International Festival Wratislavia Cantans.

As part of my cooperation with the Wrocław division of the Polish Mathematical Society and the Faculty of Mathematics and Computer Science at the University of Wrocław, in 2014 and 2017 I was the main organizer of the *Competition for a promotional poster for "The best Student Project for the theory of probability and applied mathematics"* for students of the Academy of Art and Design.

Since 2017 I have been a curator at the Łącznik Gallery (Connection Gallery) located at the Faculty of Mathematics and Computer Science at the University of Wrocław. The gallery is a meeting space for art and science, it plays an important role in integrating these two seemingly distant environments. The staff and students of the Wrocław's Academy of Art and Design and the University's meet there regularly at exhibition opening events. So far, there have been about 50 art exhibitions of works mainly by Art and Design Academy's staff and students.

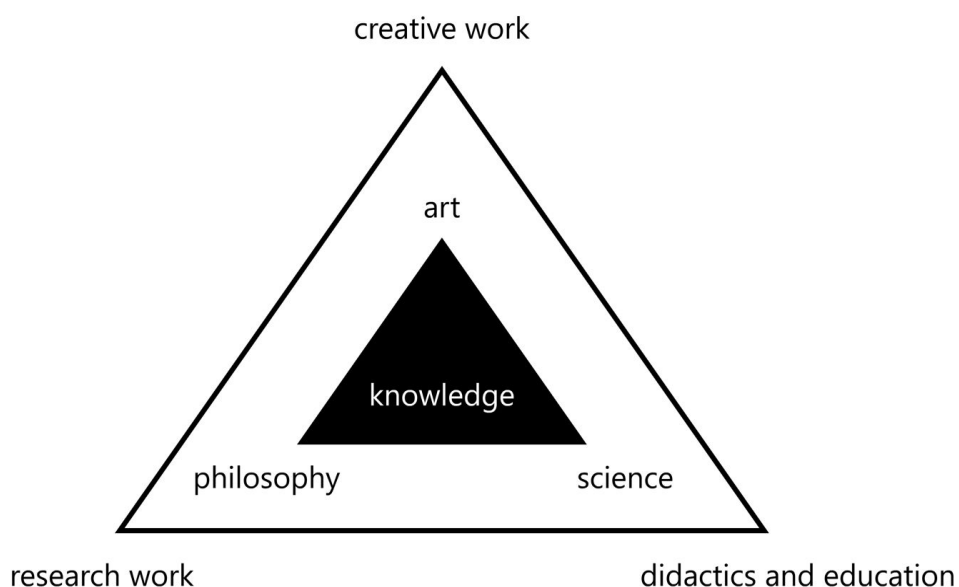
In March 2014, at the request of the Rector of the Eugeniusz Geppert Academy of Art and Design in Wrocław I was honored to speak in the Leopoldina Hall during the Doctor and Habilitated Doctor in Art promotion gala. In my short speech I presented art as an outright research field with special emphasis on the importance of its cognitive role.

I have been awarded twice by the Rector of the Eugeniusz Geppert Academy of Art and Design in Wrocław for my work at the Academy. In 2012 it was an award for organizational achievements and in 2016 it was an award for "scientific, artistic and didactic achievements and the extensive organizational activities going far beyond the Academy's operations."

## CONCLUSIONS

The main field of my professional work is focused on three areas: artistic work, research work, and didactic and educational work. While I was writing this Summary, I came to realize more and more clearly, how closely those areas are related to one another; how they inspire, supplement, correct and verify one another. A starting point for my art is scientific research – at that stage art benefits from science. The creative processing of scientific problems on the one hand makes them more accessible and attractive for the audience, and on the other hand, it provides a chance for a new, nonstandard outlook at the source problem – which have the potential for advancement in science. In both cases, science benefits from the relationship. In the first variant – when it is being popularized, and in the second one, definitely rarer but also weightier, it expands its reach. Popularizing science with the use of art naturally translates into educational and didactic work. That area, however is not only a beneficiary of the two previous ones but it also gives them something in return. In terms of popularizing science, it allows for the verification of the efficiency and adequacy of the visual message and contributes to its further optimization. In the longer perspective, that translates into propagating science. In terms of art, on the didactic and educational level, the greatness of art's cognitive role is emphasized as it's a natural visual domain – an exceptionally viable factor in our thinking. Surely, they are not all possible relationships which take place between these three areas, but they are sufficient to conclude that the structure of their interaction is very complex.

In the first chapter of this Summary I sketched a research triangle showing the symbiotic relationship of art, science and philosophy. At this point, it should be applied to the three areas of my activity where that cognitive synergy is implemented. In that way, a triangle of action is formed, in which research work, creative work, didactics and education concatenate.



15. Triangle of action: research work – creative work – education

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