Institute for Research and Applications of Fuzzy Modeling

FUZZY MODELING

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The Institute for Research and Applications of Fuzzy Modeling was intended from the very beginning as an independent scientific institution not belonging to any of the faculties. The Institute was founded in Ostrava in September 1996 under the auspices of the Minister of Education, Youth and Sports. Currently, it closely cooperates with the Departments of Mathematics and Informatics of the Faculty of Science and the Faculty of Social Studies. Fuzzy modeling is one of the main scientific directions of the University of Ostrava.

#osu #fuzzy #imageprocessing
#dynamicalsystems #research #science
#fuzzymodeling #softcomputing #ifm

FUZZY MODELING

The Institute for Research and Applications of Fuzzy Modeling (IRAFM) is a scientific place of work that is a part of the University of Ostrava. It is focused on theoretical research and practical development of various methods of fuzzy modeling, e.g. special mathematical methods that allow the development of the models that are able to handle inaccurate information. Uff.. well, but what to imagine behind it?

The classic logic is based on the presumption that a statement, e.g. „there is a cup on the table," may be true or false, and nothing else. Compared to that, in fuzzy logic, we deal with statements that are not clearly true or false. E.g. if we say „there is a big cup on the table," we can talk about whether the cup is really big or still rather small. Any number between zero and number one is expressing the truth. That is a mathematical model we are using to model the meaning of the words as „small, big, medium, deep, very long, extremely clever, cheerful" and many others. And it is just the mathematical theory developed in IRAFM that is standing behind the model. Let's note that this theory has countless interesting applications in decision making, management, forecast of future development, etc.

"*A typical mathematical article in the area of logic consists of definitions, statements, and their proofs. For a non-mathematician it looks „dryly", but as for me, I have a problem to finish the reading of a text not containing even one formula. Such a text stops being interesting for me, whereas in the mathematical article, everything makes a good sense to me*", prof. Ing. Vilém Novák, DrSc., Director of the Institute for Research and Applications of Fuzzy Modeling, describes his fondness for the field.

The Institute for Research and Application of Fuzzy Modeling is also involved in the organization of many events and international conferences, such as ISCAMI, EUSFLAT or FSTA. ISCAMI is an international student conference where doctoral students from different countries present their results among themselves. As a part of the Ostrava Fuzzy Institute, there is a number of experts from abroad, e.g. from near Poland, Ukraine, India, Vietnam or Iran. In 1996, IRAFM started with 6 people. Currently, it has 35 employees. Some of them were doctoral students at first, and then they started to work here, some of them entered the team on the basis of projects, others came on the basis of the won open competition. In terms of the projects, there are mostly foreign students included, who have completed their doctoral studies in their country, and have come to Ostrava for a several-year stay as a part of the project to support post-doctoral students.

And what are the biggest achievements of the fuzzy team? "*Previously we had good orders in the field of control and regulation, where, among others, we have invented an efficient, well-functioning, but in the same time, mathematically extremely complex application for the controlling of the aluminium smelting furnaces in Kovohutě Břidličná. However, currently we have the most applications in the field of image processing and data mining. We cooperate with the company Varroc on a large project of the long-term cross-sector research covered by the European Union. At the same time, many tasks in the research area are supported by projects and grants. We also have one project of the Technology Agency of the Czech Republic in cooperation with the Faculty of Social Studies - its aim is to create a mathematical model of social problems*", prof. Novák adds.

More about international cooperation and current projects:
ifm.osu.cz/projekty-a-mezinarodni-spoluprace/

ÚVAFM? NSC? IT4I? IFARM? IFM?

We are the Institute for Research and Application of Fuzzy Modeling.
This is the full name that can be shortened to the form of ÚVAFM (in Czech).
In 2011, we became a part of the large IT4 Innovations project, which aimed to
install and operate a supercomputer at the VSB - Technical University of Ostrava.
The project has five partners and we are one of them. As a part of IT4 Innovations,
we have therefore adopted the abbreviation IT4I also in our name, at least until the
end of 2020, when the project sustainability period ends. The title often mentioned
in publications includes also the abbreviation NSC - National Supercomputing Centre.
The abbreviations IRAFM and IFM then refer to the English name of the Institute for
Research and Applications of Fuzzy Modeling, or rather Institute of Fuzzy Modeling.
But across the university, they simply call our institute the „fuzzy institute".

FUZZY INSTITUTE AS A WORLD UNIQUENESS

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"At present, to my knowledge, our Institute for Research and Applications of Fuzzy Modeling is the only institute in the world that successfully works in the field of fuzzy modeling. We have good results in terms of both theoretical and applied research. The number of publications in the twenty-two years of the Institute's existence is close to a thousand", professor Vilém Novák says. Of course, the Ostrava fuzzy team cooperates also with foreign experts, e.g. from Spain, Belgium, Germany, the USA or Australia; one workplace supported by the government exists even in New Zealand. In the field of fuzzy modeling, however, the activity of IRAFM is the most compact. *"A competitive institute existed in Spain, but they had a problem our Institute is trying to avoid: the research focusing only on the applications and not developing the theory at the same time, will deplete, sooner or later. It is necessary to have basic research and to invent new theorems, to seek their proofs - simply to invent new theories - and then to try to apply them. This is the only way that makes sense and can work in the long term. Therefore, we have departments of theoretical as well as applied research and strive to maintain the theory. No company will subsidize the theory, but the theory is absolutely necessary to be able to invent something practical for these companies"*, professor Novák adds.

WORKING GROUPS

The Institute for Research and Applications of Fuzzy Modeling is formally divided into several expert groups:

- Formal multivalued logic and algebraic structures for fuzzy modeling
- Fuzzy natural logic (models of common human reasoning)
- Fuzzy approximation and fuzzy transform
- Data processing
- Time-series analysis and forecasting

And especially two special groups:

- The image processing group
- The dynamic systems group

WHAT TO IMAGINE UNDER THE TERMS…

Fuzzy approximation?

This area deals with special methods for the numerical solution of tasks, e.g. of differential equations on the bases of a fuzzy approach. Differential equations are several centuries old mathematical models of how to describe the physical reality and behaviour of complex systems. It was already Newton, who had started with them when he invented the differential calculus. There is a number of classical numerical methods for their solution. In IRAFM, the methods based on a fuzzy approach have been developed, which have attractive properties, and the fuzzy team has very interesting results with them.

Fuzzy control?

In practice, it often happens that a process is controlled only by a man. E.g. a crane control is done by man - crane operator. The reason may be that the mathematical description of the process is too complex, or it can be very expensive or even dangerous to obtain such a description. On the other hand, the person who manages the process can simply describe his work in natural language. When controlling the melting process in the furnace, the description may look like this: "If the temperature in the furnace is very low, we have to start to heat a lot. If it is close to the desired value, we must heat up very carefully and increase the temperature only very slowly". The fuzzy regulation method, which was developed in IRAFM, allows such instructions to be directly transformed into a computer algorithm that can manage the process similarly to a human.

Intermediated quantifiers?

In a natural language, we very often use the expressions to express how many objects we mean. Classical quantifiers are „for all" and „it exists". However, there are many others, such as "most, almost all, several, many", etc. In IRAFM, we have developed mathematical models of the meaning of these quantifiers and the way we use them in everyday language.

Time-series analysis and forecasting

Forecasting of the future development is very important in the economy. The original methods of the fuzzy team can estimate the future development of the time-series quite effectively. In practice, we can imagine this situation when buying euros in an exchange office. The exchange rate is changing every day, alternately decreasing and increasing. This exchange rate is measured in time moments. And the euro exchange rate graph in the course of days is just the time-series.

IMAGE PROCESSING GROUP (VISION GROUP)

A group of experts in the field of image processing, or computer vision and machine learning, is developing its own theory and methods for industrial applications. At the University of Ostrava, this team is led by prof. Irina Perfiljeva.

Portfolio of what can be solved by using the image and video processing in real-time

- Automated reading of characters and symbols, object recognition, even if their images are damaged, indistinct or rotated in any way.

- Inpainting - reconstruction of damaged images, filling of missing parts.

- Recognition and objects contours marking (so-called „edge detection").

- Super-resolution, fusion and other methods used, for example, to enhance image quality.

- Automated defectoscopy.

DYNAMIC SYSTEMS GROUP (DYNAMICS GROUP)

The mathematical essence of a dynamic system is a point moving in time. It is a highly abstract mathematical discipline in which the system is modeled as a function, i.e. a formula that gives (another) output number based on the input number. The output is constantly sent over and over into the same function, theoretically infinitely times. A well-known example is the so-called Sierpiński carpet. Different shapes of motion, the properties of which are studied in detail, can be the result. These are interesting problems that are mathematically quite difficult. At the University of Ostrava, the dynamic system group consists of experts from abroad led by Assoc. Prof. Kupka.
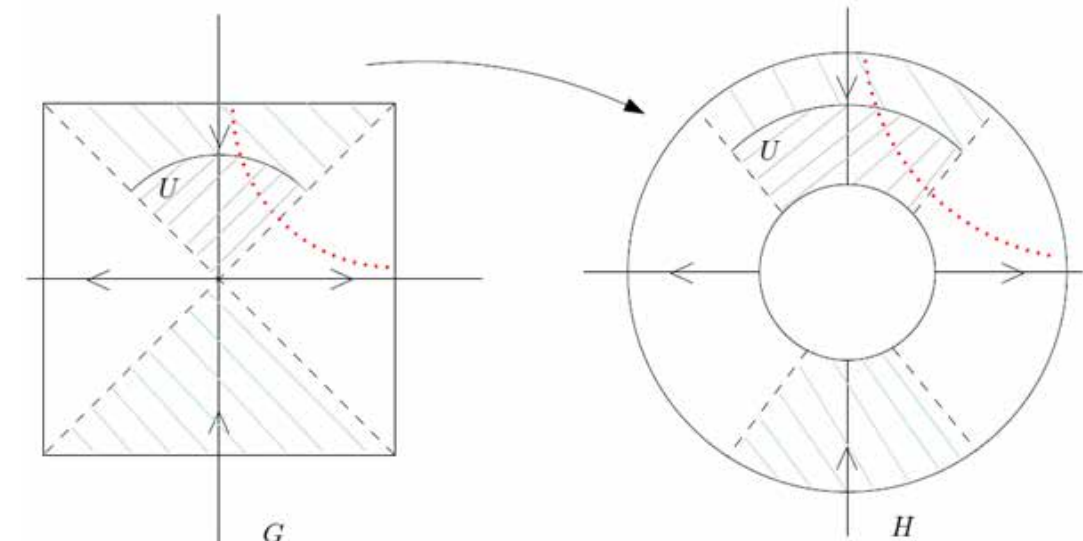
SOLVED PROJECTS OR FUZZY MODELING APPLICATION IN PRACTICE

Jewellery stones classification

The project for the glass company Preciosa consisted in recognizing jewellery stone defects with an accuracy of more than 99%, and at a speed exceeding 200 stones per second. The purpose was to exclude the stones with the cracks or with other defects.

Automated car license plates recognition

Recognition of car license plates in the full operation and in any weather is difficult because often the car plate is dirty or snowy or is recorded in fog. The aim of the project was to create a software being able to find car licence plate and to recognize the individual signs of this registration number in the picture of a car. The second problem in recognition is that the car license plates of European countries differ one from another, have different shapes and different locations on the car. The application created in IRAFM can recognize the license plates of all European countries' cars, at any season of the year, regardless of daylight.
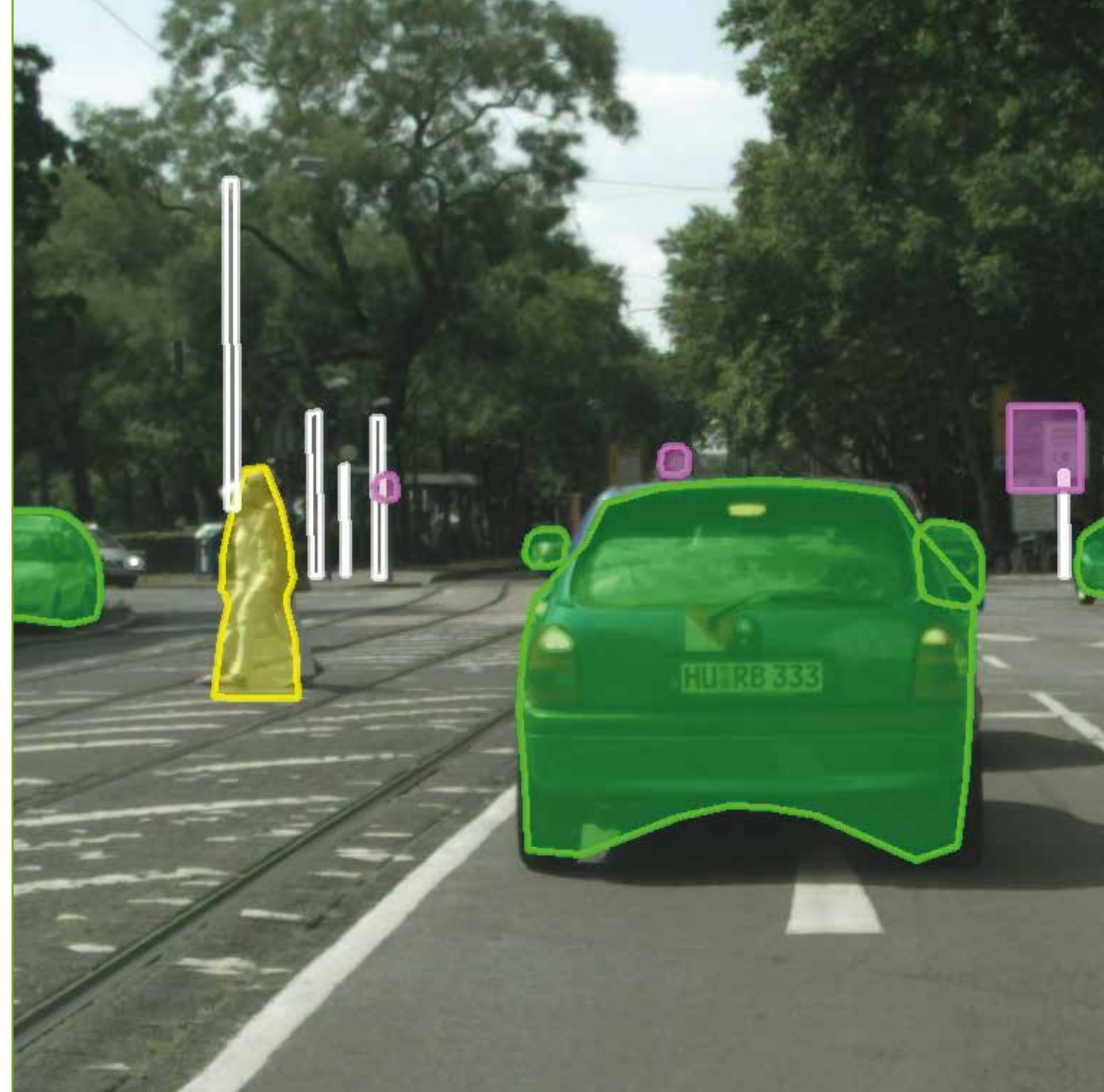
CONTACT PERSONS

Guarantor of the research direction

prof. Ing. Vilém Novák, DrSc.
Director of the The Institute for Research and Application of Fuzzy Modeling
e-mail: vilem.novak@osu.cz

Assoc. Prof. RNDr. Martin Štěpnička, Ph.D.
Deputy Director
Head of Applied Research Department

prof. Irina Perfiljeva, CSc., dr. h. c., prof. h. c.
Head of Theoretical Research Department

RNDr. Viktor Pavliska, Ph.D.
Head of Software Development Department

UNIVERSITY OF OSTRAVA
INSTITUTE FOR RESEARCH
AND APPLICATIONS
OF FUZZY MODELING

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