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**SILESIA N UNIVERSITY OF TECHNOLOGY**  
**FACULTY OF AUTOMATIC CONTROL, ELECTRONICS**  
**AND COMPUTER SCIENCE**

**PROGRAMME: INFORMATICS**

Final Project

Title of engineer thesis

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# Abstract

The text of the abstract should be copied into a respective field in the APD system.  
The Abstract with keywords should not exceed one page.

**Keywords:** 2-5 keywords, separated by commas



# Chapter 1

## Introduction

- introduction into the problem domain
- settling of the problem in the domain
- objective of the thesis
- scope of the thesis
- short description of chapters
- clear description of contribution of the thesis's author – in case of more authors  
table with enumeration of contribution of authors





# Chapter 2

## [Problem analysis]

- problem analysis
- state of the art, problem statement
- literature research (all sources in the thesis have to be referenced [1, 2, 4, 3])
- description of existing solutions (also scientific ones, if the problem is scientifically researched), algorithms, location of the thesis in the scientific domain



# Chapter 3

## Requirements and tools

- functional and nonfunctional requirements
- use cases (UML diagrams)
- description of tools
- methodology of design and implementation



# Chapter 4

## External specification

- hardware and software requirements
- installation procedure
- activation procedure
- types of users
- user manual
- system administration
- security issues
- example of usage
- working scenarios (with screenshots or output files)



Figure 4.1: Figure caption (below the figure).



# Chapter 5

## Internal specification

- concept of the system
- system architecture
- description of data structures (and data bases)
- components, modules, libraries, resume of important classes (if used)
- resume of important algorithms (if used)
- details of implementation of selected parts
- applied design patterns
- UML diagrams

Use special environment for inline code, eg **descriptor** or **descriptor\_gaussian**. Longer parts of code put in the figure environment, eg. code in Fig. 5.1. Very long listings—move to an appendix.

---

```

1 class descriptor_gaussian : virtual public descriptor
2 {
3     protected:
4         /** core of the gaussian fuzzy set */
5         double _mean;
6         /** fuzzyfication of the gaussian fuzzy set */
7         double _stddev;
8
9     public:
10        /** @param mean core of the set
11            @param stddev standard deviation */
12        descriptor_gaussian (double mean, double stddev);
13        descriptor_gaussian (const descriptor_gaussian & w);
14        virtual ~descriptor_gaussian();
15        virtual descriptor * clone () const;
16
17        /** The method elaborates membership to the gaussian
18            fuzzy set. */
19        virtual double getMembership (double x) const;
20 };

```

---

Figure 5.1: The **descriptor\_gaussian** class.



# Chapter 6

## Verification and validation

- testing paradigm (eg V model)
- test cases, testing scope (full / partial)
- detected and fixed bugs
- results of experiments (optional)



# Chapter 7

## Conclusions

- achieved results with regard to objectives of the thesis and requirements
- path of further development (eg functional extension ...)
- encountered difficulties and problems

Table 7.1: A caption of a table is **above** it.

| method  |         |         |                |              |              |                      |                |
|---------|---------|---------|----------------|--------------|--------------|----------------------|----------------|
| $\zeta$ | alg. 1  | alg. 2  | alg. 3         |              |              | alg. 4, $\gamma = 2$ |                |
|         |         |         | $\alpha = 1.5$ | $\alpha = 2$ | $\alpha = 3$ | $\beta = 0.1$        | $\beta = -0.1$ |
| 0       | 8.3250  | 1.45305 | 7.5791         | 14.8517      | 20.0028      | 1.16396              | 1.1365         |
| 5       | 0.6111  | 2.27126 | 6.9952         | 13.8560      | 18.6064      | 1.18659              | 1.1630         |
| 10      | 11.6126 | 2.69218 | 6.2520         | 12.5202      | 16.8278      | 1.23180              | 1.2045         |
| 15      | 0.5665  | 2.95046 | 5.7753         | 11.4588      | 15.4837      | 1.25131              | 1.2614         |
| 20      | 15.8728 | 3.07225 | 5.3071         | 10.3935      | 13.8738      | 1.25307              | 1.2217         |
| 25      | 0.9791  | 3.19034 | 5.4575         | 9.9533       | 13.0721      | 1.27104              | 1.2640         |
| 30      | 2.0228  | 3.27474 | 5.7461         | 9.7164       | 12.2637      | 1.33404              | 1.3209         |
| 35      | 13.4210 | 3.36086 | 6.6735         | 10.0442      | 12.0270      | 1.35385              | 1.3059         |
| 40      | 13.2226 | 3.36420 | 7.7248         | 10.4495      | 12.0379      | 1.34919              | 1.2768         |
| 45      | 12.8445 | 3.47436 | 8.5539         | 10.8552      | 12.2773      | 1.42303              | 1.4362         |
| 50      | 12.9245 | 3.58228 | 9.2702         | 11.2183      | 12.3990      | 1.40922              | 1.3724         |



# Bibliography

- [1] Name Surname and Name Surname. Title of an article in a journal. *Journal Title*, 157(8):1092–1113, 2016.
- [2] Name Surname and Name Surname. *Title of a book*. Publisher, Hong Kong, 2017.
- [3] Name Surname, Name Surname, and N. Surname. Title of a web page. `http://somewhere/in/internet.html`. [access date: 2018-09-30].
- [4] Name Surname, Name Surname, and N. Surname. Title of a conference article. In *Conference title*, pages 5346–5349, 2006.



# Appendices





# Index of abbreviations and symbols

DNA deoxyribonucleic acid

MVC model–view–controller

$N$  cardinality of data set

$\mu$  membership function of a fuzzy set

$\mathbb{E}$  set of edges of a graph

$\mathcal{L}$  Laplace transformation



# Listings

(Put long listings in the appendix.)

---

```
1 partition fcm_possibilistic::doPartition  
2 (const dataset & ds)  
3 {  
4     try  
5     {  
6         if (_nClusters < 1)  
7             throw std::string ("unknown_number_of_clusters");  
8         if (_nIterations < 1 and _epsilon < 0)  
9             throw std::string ("You_should_set_a_maximal_  
            number_of_iteration_or_minimal_difference--_  
            epsilon.");  
10        if (_nIterations > 0 and _epsilon > 0)  
11            throw std::string ("Both_number_of_iterations_and_  
            minimal_epsilon_set--you_should_set_either_  
            number_of_iterations_or_minimal_epsilon.");  
12  
13        auto mX = ds.getMatrix();  
14        std::size_t nAttr = ds.getNumberOfAttributes();  
15        std::size_t nX    = ds.getNumberOfData();  
16        std::vector<std::vector<double>> mV;  
17        mU = std::vector<std::vector<double>> (_nClusters);  
18        for (auto & u : mU)  
19            u = std::vector<double> (nX);  
20        randomise(mU);  
21        normaliseByColumns(mU);  
22        calculateEtas(_nClusters, nX, ds);  
23        if (_nIterations > 0)  
24        {  
25            for (int iter = 0; iter < _nIterations; iter++)  
26            {
```

```
27         mV = calculateClusterCentres(mU, mX);
28         mU = modifyPartitionMatrix (mV, mX);
29     }
30 }
31 else if (_epsilon > 0)
32 {
33     double frob;
34     do
35     {
36         mV = calculateClusterCentres(mU, mX);
37         auto mUnew = modifyPartitionMatrix (mV, mX);
38
39         frob = Frobenius_norm_of_difference (mU, mUnew)
40             ;
41         mU = mUnew;
42     } while (frob > _epsilon);
43 }
44 mV = calculateClusterCentres(mU, mX);
45 std::vector<std::vector<double>> mS =
46     calculateClusterFuzzification(mU, mV, mX);
47
48 partition part;
49 for (int c = 0; c < _nClusters; c++)
50 {
51     cluster cl;
52     for (std::size_t a = 0; a < nAttr; a++)
53     {
54         descriptor_gaussian d (mV[c][a], mS[c][a]);
55         cl.addDescriptor(d);
56     }
57     part.addCluster(cl);
58 }
59 return part;
60 }
61 catch (my_exception & ex)
62 {
63     throw my_exception (__FILE__, __FUNCTION__, __LINE__,
64         ex.what());
65 }
```

```
63     catch (std::exception & ex)
64     {
65         throw my_exceptionn (__FILE__, __FUNCTION__, __LINE__,
66                               , ex.what());
67     }
68     catch (std::string & ex)
69     {
70         throw my_exception (__FILE__, __FUNCTION__, __LINE__,
71                               ex);
72     }
73     catch (...)
74     {
75         throw my_exception (__FILE__, __FUNCTION__, __LINE__,
76                               "unknown_exception");
77     }
78 }
```

---



# CD/DVD content

The thesis is accompanied by a CD containing:

- thesis ( $\text{\LaTeX}$  source files and final `pdf` file),
- source code of the application,
- test data.





# List of Figures

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