Online Fuzzy-C-Means clustering

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Abstract

In this paper you will find short information about the program of Online Fuzzy-Clustering.
To understand the background processes, it gives a summary of the architecture and basics of the communications, to positioning it shows the software and hardware requirements of both: the server and the client side. Because the practice is the best way to usage, it guides on the whole process that a new 'customer' has to do while presents some screenshots of the working program surface. And finally it also provides some working interest and inside tricks. This documentation will not touch upon the mathematical issue of the applied Fuzzy C-means Clustering Algorithm although it based on it [FCM]. It concentrates on the technical implementation.

1. Technical summary

1.1. Architecture and Communication basics

If we want to categorise this application than we can say it can deliver its service across the Web; it is based on 3-tier (layer) architecture logic: the *Client-tier*, the *Application Logic-tier*, and the *Data*-tier. (Figure 1.) These tiers are separated basically on the understanding its functionality instead of the location of them. In the present working configuration the *Application Logic* and the *Data-tiers* are installed on the same machine, and of cause a *Client-tier* also can start from this machine.

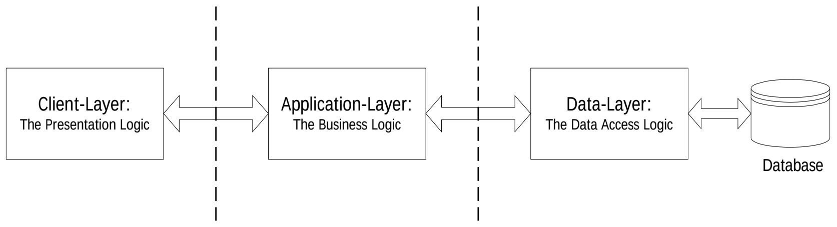


Figure 1. The 3-tier Architecture

The communication between the *Client* and the *Application Logic-tier* based on industry standards HTTP protocol without any encryption, but the HTTPS protocol can supplements easily without changing any of the core application code.

In the *Client-tier* a Web Browser downloads the dynamically generated web pages, and sends them back to the *Application-tier* with the filled input fields in it for next pages to get [Apache]+[Tomcat]. The *Application-tier* collects, checks and interprets the information from the *Client-tier* and the *Data-tier,* as well as it executes commands and runs the main function: the fuzzy clustering algorithm with the specified parameters and data [Tomcat]+[FCM]. Finally it also generates dynamic web pages for the actual user with the actual information (data and/or input fields) on it [Tomcat].

The communication between the *Application Logic* and the *Data-tier* is based on the standard 'jdbc' driver.

1.2. Software and hardware requirements

Because the applied component, there are some software and hardware requirements before we can start work with the Fuzzy on-Line Application. At first, we have to install the *Data* and the *Application Logic-tier* (back-end) than we have to start these services before we can get contact them from an installed Client.

1.2.1. Back-end requirements

The server implements the *Application Logic-tier* needs to be installed with a Web-server [Apache], a Java Software Development Kit [Java], and a Java Server Pages Engine [Tomcat]. For the database server connection the Java environment has to be extended with the jdbc-driver of the applied database server, too.

The server implements the *Data-their* needs to be installed with same database server [MySQL], which is configured at the *Application Logic-tier* and needs to be configured for it. (Database, tables, accounts, grants…)

All of the listed software components also have software and hardware requirements, the Fuzzy on-Line Application has no more extension to them; its recommendations can be followed. All of them installable on several OS including Linux, Windows 98/NT/2000…

1.2.2. Front-end requirements

In the client-side there are much easier things to do, only the Web Browser has to be installed; unfortunately the present systems is optimised only for the Internet Explorer 4.0 or above with JavaScript and cookie acceptances.

1.3. The properties of the present working system

The present working system is located in the College of Nyíregyháza based on the college's hardware and infrastructure. The server machine has an Intel Pentium 233MHz CPU, 128MB RAM, 10/100 MB Network card installed in the public domain network; DN: pingvin.nyf.hu, and the application's service works on port: 8080. The *Application Logic* and *the Data-tiers* are implemented on the same machine (this server). All of the installed software components are under the GNU/Open Source/Freeware licence/policy:

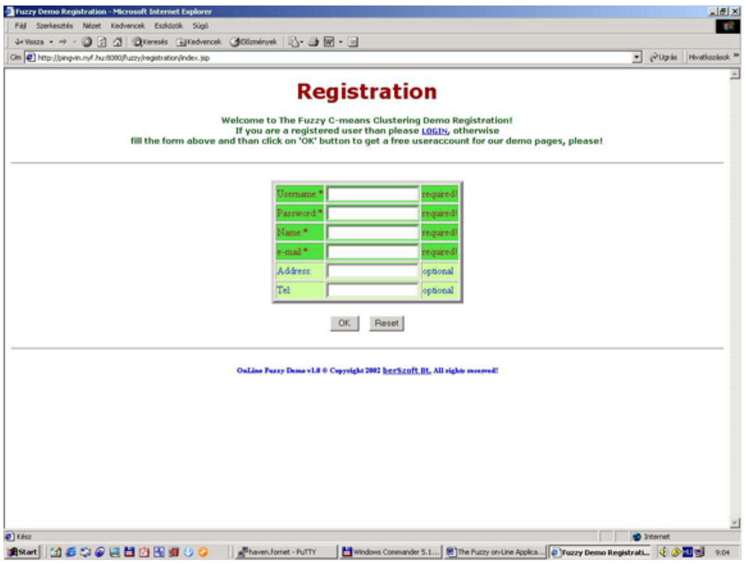
- OS: Debian-Linux;
- Web-server: Apache v1.3.39 [Apache];
- JSDK: Sun J2SE v1.3.1 [Java];
- JSP Engine: Tomcat 3.3.1 [Tomcat];
- Database Server: MySQL 3.23.37 [MySQL];
- Application Source: Java [FCM].

2. Using the Fuzzy on-Line Application

There are two different levels of the Fuzzy on-Line Application's usage. The first level is called 'demo' where some parameters and the size of the input data matrix are limited. In the second level is called 'full' where are no limitations for any parameters or data. The 'demo' level is open for everyone who has already registered (the registration very easy and it is free), while the 'full' level is open for only members. The both levels having run the same application, the only difference is the limitations.

2.1. Registration

Every new user has to be registered before she/he can start the Fuzzy on-Line Application. (Figure 2.) In the registration form there are some mandatory and some optional fields, and every new user has to be asked for a unique username before her/his data will be acceptable by the system. Only successfully registered users can come in to the next pages. The username and the password set before have to repeat all the times she/he comes back to the login page. The user's information will be saved in the user table for future contact.



Registration

Welcome to The Fuzzy C-means Clustering Demo Registration!
If you are a registered user than please LOGIN, otherwise
fill the form above and than click on 'OK' button to get a free useraccount for our demo pages, please!

Username:*		required!
Password:*		required!
Name:*		required!
e-mail:*		required!
Address:		optional
Tel:		optional

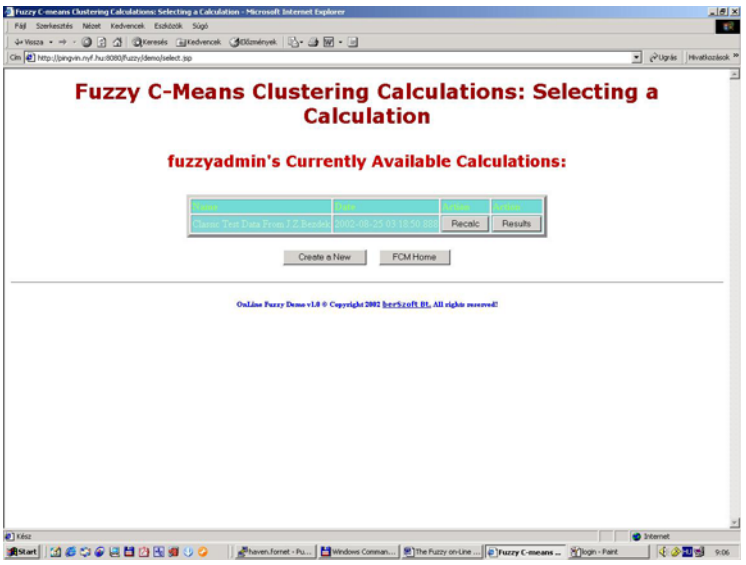
OnLine Fuzzy Demo v1.0 © Copyright 2002 herSzoft Bt. All rights reserved!

Fuzzy Demo Registration - Microsoft Internet Explorer
http://pingvin.nyf.hu:8080/fuzzy/registration/index.jsp
OK
Reset

Figure 2. The Registration Form

2.2. The User's own Calculations

There is one predefined (demo) data available for everyone, based on artificial data set was originally published by J. C. Bezdek, and every new calculation/recalculation also will be listed in the user's calculations table. This nice feature of the system is available right after the login screen when has to be decided if a recalculation from the list or new calculation will be started. (Figure 3.) There is a possibility for every user to name her/his calculations in the input parameter section and reuse a complete data table more than once, and/or recalculate them with another parameter setting and/or change the input data table. To have a look at once more to the results of a finished calculation is also available for all of the listed calculations.


Fuzzy C-Means Clustering Calculations: Selecting a Calculation

fuzzyadmin's Currently Available Calculations:

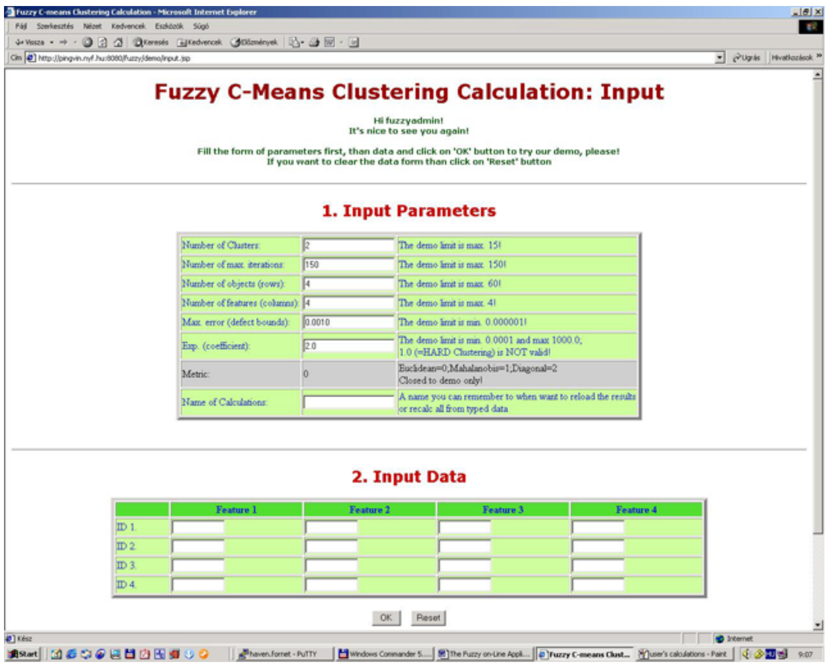
Name	Date	Action	Action
Classic Test Data From J.Z.Bezdek	2002-08-25 03:18:50.888	Recalc	Results

Create a New
FCM Home
OnLine Fuzzy Demo v1.0 © Copyright 2002 berSzoft Bt. All rights reserved!

Figure 3. The Table of User's Calculations

2.3. Preparing Parameters and Data

The next step is to set the parameters and the input data want to be grouped. While changing some parameters like number of features and/or objects, the input page can be reloaded to redraw the input data table that's way it is recommended to set the parameters first than set the input data. (Figure 4.) If any of the parameters or the input data will not be filled up the Browser (the *Client-tier)* warns the user to correct before the page to be sent to the server (the *Application-tier*)



Fuzzy C-Means Clustering Calculation: Input

Hi fuzzyadmin!
It's nice to see you again!

Fill the form of parameters first, than data and click on 'OK' button to try our demo, please!
If you want to clear the data form than click on 'Reset' button

1. Input Parameters

Number of Clusters:	2	The demo limit is max. 15!
Number of max. iterations:	150	The demo limit is max. 150!
Number of objects (rows):	4	The demo limit is max. 60!
Number of features (columns):	4	The demo limit is max. 4!
Max. error (defect bounds):	0.0010	The demo limit is min. 0.000001!
Exp. (coefficient):	2.0	The demo limit is min. 0.0001 and max 1000.0; 1.0 (=HARD Clustering) is NOT valid!
Metric:	0	Euclidean=0;Mahalanobis=1;Diagonal=2 Closed to demo only!
Name of Calculations:		A name you can remember to when want to reload the results or recalc all from typed data

2. Input Data

	Feature 1	Feature 2	Feature 3	Feature 4
ID 1.				
ID 2.				
ID 3.				
ID 4.				

Figure 4. Setting up the Parameters and the Input Data Table

2.4. Confirming

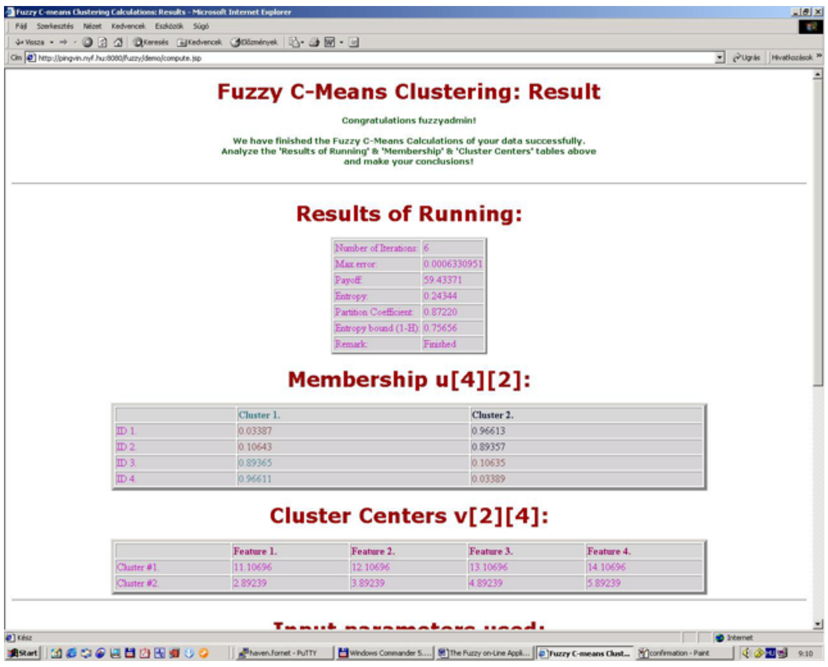
Before the actual calculations starts the user is asked to confirm the input parameters and data the server received. There is one more chance to correct any of them if it does not fit to the user needs. Pushing the 'Start' button, the server will pass all of this input information to the database server (the *Data-tier*) and invokes the calculating algorithm.

2.5. Calculating

During the calculations the Client automatically refresh its screen to check the status of the running algorithm and to show the actual process rate of the calculations.

2.6. Summary of the Results

If the calculation process finishes, the user's refresh request automatically pass to the Result of the calculations page (Figure 5.), including the main parameters of the FCM algorithm, the Membership Matrix, the Cluster Centres' Matrix and once more the Input parameters and data table. While all of these information automatically saved for future analysis in the database server than the validation is one of the next user's tasks before the final conclusions.


Fuzzy C-means Clustering Calculations: Results - Microsoft Internet Explorer
Fájl Szerkesztés Nézet Kedvencek Eszközök Súgó
http://pingvin.nyf.hu:8080/fuzzy/demo/compute.jsp

Fuzzy C-Means Clustering: Result

Congratulations fuzzyadmin!

We have finished the Fuzzy C-Means Calculations of your data successfully.
Analyze the 'Results of Running' & 'Membership' & 'Cluster Centers' tables above
and make your conclusions!

Results of Running:

Number of Iterations:	6
Max error:	0.0006330951
Payoff:	59.43371
Entropy:	0.24344
Partition Coefficient:	0.87220
Entropy bound (1-H):	0.75656
Remark:	Finished

Membership u[4][2]:

	Cluster 1.	Cluster 2.
ID 1.	0.03387	0.96613
ID 2.	0.10643	0.89357
ID 3.	0.89365	0.10635
ID 4.	0.96611	0.03389

Cluster Centers v[2][4]:

	Feature 1.	Feature 2.	Feature 3.	Feature 4.
Cluster #1.	11.10696	12.10696	13.10696	14.10696
Cluster #2.	2.89239	3.89239	4.89239	5.89239

Figure 5. Summary of the Results

3. Secret of the trade

3.1. Loading and Performance

The implemented software (the *Application-tier*) has no load balancing and/or fail over component. In the other hand the other applied software components (like OS, DB, JSP…) provides several opportunities to have minimal or higher fail over and/or load balancing feature: like raiserfs file system, db tuning, JSP concurrent user account limitation, session time… Why java can devour the memory of the system, more memory always can be a good choice ;-)

3.1.1. Sessions

Every client who opens any of the pages from the server (downloads a Web-page) in her/his Browser's window invokes a new session in the server-side. One user has one session for one open Browser's window, but the same session belongs to her/him while she/he goes through the pages of the Fuzzy on-Line Application on the same Browser's window. The sessions have unique identifications and every session automatically ends if there is no activity from the client-side for more than half an hour.

3.1.2. Threads

Every session what starts the FCM calculations also starts a new thread for it in the JVM (Java Virtual Machine). In this case the session has its new thread if the user has confirmed the input parameters and table. There is only one 'calculating-thread' for a session in its lifecycle even if the user starts a new calculations/recalculations with the same session.

3.2. Database tricks

While a new user registers herself/himself the application pass her/his data to the database server and creates a new role for her/him, as well. The roles are the other technique of the applied security techniques (the first are the username/password). With roles the user can be grouped and one user can be a member of more than one group, too. One of the groups has rights to run the 'full' version of the application. The basic role what every successfully registered user will get the 'demouser' (a right to run the enter the demo application zone).

The precision of the number drawing under the calculations is different than the precision of it in the database. During the calculation the java double type is used, while the demo database was configured to store the data as decimal (20,10) and decimal (15,5).

4. Future plans

In the near future we plan to integrate an SVG and/or Chart based graphical summeries into the Results of Calculations, and to implement an XLS type input data entry and output copy as well. These developments are also plan to base on GNU/Open source projects using the POI, JFreeChart and SVG. Every comment is welcome! Have fun and see you at our demo pages!

5. References

[FCM] – The Fuzzy C-means Clustering Algorithm, TDK Essay, 1991 MGF Nyíregyháza : Kancsár Dezső

[Java2] - Java 2 Platform API Specification (V1.3.1): Sun Microsystems, Inc.

[Apache] – Apache HTTP Server V1.3 Documentation: Apache HTTP Server Documentation Project.

[Tomcat] - Tomcat Documentation (V3.3.1): The Apache Software Foundation

[MySQL] - MySQL Programmers Guide (V3.3.27): MySQL