CASOM: SOM FOR CONTINGENCY TABLES AND BIPLOT

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Abstract - This article presents a new way of dealing with the self-organizing map methods to visualize by an original way qualitative data or histogram vectors as we can find on the Internet e.g. after the pre-processing of plain text documents. The main difference with other known methods is the nature of the processed matrix: a contingency table. By adding constraints during the learning of a mixture of a discrete distribution which models the noise in classes of documents or rows, we obtain a self-organizing map algorithm named CASOM. We explain the properties of the model: metrics, criteria, links with Correspondence Analysis and mean biplot which help to better interpret results. A more general projection available for self-organizing maps in the dual Euclidian space or columns is also introduced. Then, we present some experiments on a corpus of textual short summaries to illustrate the behavior of the algorithm and to show its interest. The conclusion discusses alternative models and gives perspectives of the contribution.

Key words - Self-Organizing Map, Expectation-Maximization, Correspondence Analysis, Biplot, Textual data analysis

1 Introduction

Self-organizing maps methods were created by Kohonen in the early 1980's. Roughly speaking, Kohonen maps seek to approximate discretized surfaces to model correlation statistics and summarize data distribution. In practice, it is a K-mean^[1] algorithm whose classes are constrained on an imaginary lattice. During the learning process, the centers of the classes are updated as in the K-mean method. But all the centers which are near a given center on the lattice also share the data they belong to. So, this smoothing process allows centers which are neighbors on the lattice, to be near each other in the data space. One of the greatest interests of the SOM method is to generalize the principal planes from the Principal Component Analysis method^[2] (PCA) in a non-linear way. Correspondence Analysis^[3] (CA), a PCA variant for dealing with contingency tables is a very efficient method to extract a structure from an histogram data cloud. Nevertheless, it needs to evolve and to be scaled to be suitable for the huge databases available nowadays. A few years ago, a method KPCA was presented [4] to deal with such data. As CA is like a PCA with a χ^2 metrics, Self-Organizing Maps^[5] was applied to this metrics. This method has not yet been used for textual data and give center vectors as continuous multivariables. Here, we propose an alternative approach by modeling classes with multinomial distributions. This last law is today one of the

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best ways to classify[6] texts and can deal successfully with the very sparse textual matrices. Therefore, it seems judicious to include it in the model. As alternative models, we can cite the works[4, 7] which study a stochastic version of SOM with a χ^2 metrics for categorical data. This method should be adapted to construct our dual projections for SOM. Several parametric models have also been proposed these past years as a categorical version of the Generative Topographic Model[8]. These models are quite complex, hard to estimate for large corpuses and to interpret. Our work uses the original decreasing vicinity of SOM during the learning phase. Another work[9] projects the original Probabilistic Latent Semantic Model in the same way, needing more variables to be estimated. Other methods to project data on a plane exist like the classical Multidimensional Scaling (MDS), e.g. Sammon's maps[10], known for its difficulty to be estimated and for the sometimes confusing interpretation of the proximities on the resulting map.

In the following, first we describe the CASOM model that we propose and gives some justifications. Then a biplot method is presented and extented towards a *dual projection* for SOM methods. Then we report the experimental results performed and finally we draw our conclusions. We will mainly analyze textual data as abstracts from scientific articles available on-line. We call *document* (or *text*) a histogram data vector and *term* (or *word*) the component of a *textual* vector. In a formal way, let us suppose we have a corpus of I documents $\mathcal{D} = \{d_i\}_{i=1}^{i=I}$ where d_i represents the *i*th document " $m_{i_1}m_{i_2}\cdots m_{i_|d_i|}$ ", the m_{i_j} are the words of the *i*th document. From that corpus, a vocabulary of J terms $\mathcal{V} = \{m_j\}_{j=1}^{j=J}$ is extracted. In practice, we select \mathcal{V} by calculating the total frequency of each term and keeping the first J terms because of the Zip law[11]. The document matrix is built counting the occurrences of each word from \mathcal{V} . Let us have $N_{ij} = \#\{m_{it} = m_j, t \in [1; |d_i|]\}, d_i = (N_{i1}, N_{i2}, \cdots, N_{iJ})^T$, and $N_{i\bullet} = \sum_j N_{ij}, N_{\bullet j} = \sum_i N_{ij}, N_{\bullet \bullet} = \sum_i \sum_j N_{ij}$. The contingency table is built with the d_i as lines, and m_j as columns.

2 CASOM: Generalized Correspondence Analysis

Our algorithm is based on the Topology Preserving Expectation-Maximization or TPEM from [12] which modifies the Classifying EM[13] (CEM) algorithm. This one is a clustering version of the Expectation-Maximization [14] (EM) algorithm where EM is an algorithm to calculate the local maximum of likelihood with latent random variables. Therefore, it is a SOM-like map built with explicit Gaussian distribution for the classes. The counting vectors d_i are now supposed to be i.i.d. realizations of discrete multidimensional random variables following a multinomial law. The algorithm is a clustering process using a mixture of discrete laws with a fuzzification μ_{ik} of the original binary variables c_{ik} which is one if d_i is in class k and zero else, like in a SOM algorithm. During the learning process, the vicinity is reduced to zero when there is no more neighborhood. TPEM is justified by its authors because the CEM of identical isotropic Gaussian laws is equivalent to a K-mean procedure. The Gaussian class distribution can also be argued by the asymptotic properties [15] of the SOM. Since our current model is different, we seek the underlying metrics and discuss some statistical properties of the algorithm. Here θ is the parameter vector merging all unknown variables $P_{i|k}$ (multinomial parameter component), P_k (mixing component), and μ_{ik} . So, the algorithm is a likelihood maximization of a mixture of multinomial distributions by an EM process with a forced fuzzification of the a posteriori probabilities before the maximization step. It enables

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lateral links between close centers in the lattice. In practice, the batch algorithm encounters what is called a *dead unit* (class center) when no document is assigned to the corresponding class. Besides, as smoothing decreases, μ_{ik} is binary or almost binary, so that $P_{\bullet|k}$ cannot be estimated because the class is empty. In that case, we do not update its value any longer. Thus, we obtain our CASOM algorithm of self-organizing map. Distribution values are initialized with random values or in a more suitable way, with already organized centers as a grid from some linear factorial method. Generally, to display the final map, one uses the U-matrix[16, 17] which shows the local correlation between the closest neighbor classes. A clustering of the class centers, e.g. hierarchical clustering[18], facilitates browsing on the map by permitting the user to focus on the main themes revealed. For the model presented, we propose the natural criterion by analogy with SOM, replacing Euclidian distance by KL distance, where the binary variable h_{kl} is 1 iff e_k and e_l are neighbor or identical:

$$\mathcal{L}_C(\mathcal{D}|\theta) = \sum_i f_i \sum_k \mu_{ik} \sum_l h_{kl} KL(f_{\bullet|i}||P_{\bullet|k})$$

This last criterion is approximately [19] minimized by CASOM, ignoring the Bayesian smoothing and near convergence when the centers are well organized. And, we have an approximate local χ^2 metrics, remembering that of Malahanobis : the distance locally adapts [19] itself to each class center:

$$KL(f_{\bullet|i}||\hat{P}_{\bullet|k}) \approx \frac{1}{2} \sum_{j} \frac{1}{\hat{P}_{j|k}} \left(f_{j|i} - \hat{P}_{j|k} \right)^2$$

Because of the stochastic fluctuation around the mean value, it can also be shown that this last criterion is distributed as a normal law when min_iN_i grows towards infinite values. Morever, as SOM is a non-linear PCA method, the distance justifies that our model is an approximate generalization of the CA method, as the underlying metrics is near the χ^2 one. We call the method CASOM for CA by SOM. Our method also permits a very specific visualization of a corpus by showing rows and columns of a two-way contingency table. We use mean projections of words and documents by showing a document d_i at the Euclidian coordinates $\langle s|d_i;\hat{\theta} \rangle$ and a word m_j at the Euclidian coordinates $\langle s|m_j;\hat{\theta} \rangle$ where we have:

It is clear that we must be careful with multimodal distributions showing documents and words at spurious places. So, we choose to select from the finite vocabulary \mathcal{V} only low entropy $\hat{\mathcal{H}}(m_j)$ terms to limit mistakes, with $\hat{P}(k|m_j) \propto \hat{P}_{j|k}$ (or possibly $(\hat{P}_{j|k})^{\alpha}$ with $\alpha > 1$ to underline modes of the distribution). Some edges can be added between very near class distributions, i.e. with small distances D as $D(\hat{P}(k|\Box_1), \hat{P}(k|\Box_2))$ where $\Box_l \in \mathcal{D} \cup \mathcal{V}$. This biplot is a main difference between the original SOM and CASOM: we are able to interpret term statistics and to make comparisons between documents, classes and terms on the same bidimensional map. For classical SOM methods, where centers are continuous, we propose an alternative. Knowing the fact that the K-means is equivalent to a CEM of a mixture of gaussian law with spherical and identical variance matrices, we can write $P(k|m_j) \propto exp(-\rho\sum_i (x_{ij} - c_{jk})^2)$ which, for a good ρ , and c_k a center in \mathbb{R}^J , reveals most of the explained intra-variance.

3 Experimental and empirical results

The projected corpus comes from the summaries of the technical home publications of INRIA (http://www.irisa.fr/bibli/publi/), of the past 10 years. These scientific abstracts cover all the research themes of the INRIA institute: 1) Networks and systems, 2) Software engineering and Symbolic calculus, 3) Human-Machine Interface and 4) Simulation and optimization of complex systems. These abstracts are in two languages, French and English. The factorial planes of the multinomial parameters come from the French version with a vocabulary of 480 words. We project this corpus of 1,961 documents on a 12*10 knot mesh and extract a quick view of its content. For these French summaries, we decide to stop the algorithm before near convergence. We noticed a clear empirical link of the properties between CA and CASOM in the Figure 1. We also project the English version of the abstracts, learning the map until the end of the convergence. We thus obtain a well-trained map with natural clusters. Here, for a vocabulary of 476 words, we retain only 1,955 texts. The size of the textual vectors is near the French one. SOM-like methods index data in *semantic* clusters where they can be retrieved by a user providing a query $d_q = (N_{q1}N_{q2}\cdots N_{qJ})$. A Boolean treatment is for instance the intuitive value $\sum_{j:N_{qj}>0} \hat{P}_{j|k}$. We are able to provide different maps to a user, in the Figure 2 underlying various features of the data map by drawing the values as level lines. We illustrate the browsing property of the model. This corresponds to activation maps with level lines for the sum of probabilities of the multinomial for the queries "knowledge" and *"interface"* with the part of the subgraph around each projected word. Any other indicator could be used instead of the probabilities. The figures show how the self-organizing map behaves: it is activated on different zones according to the diverse themes of the corpus. For example, the word *knowledge* is statistically near the word *interface* as is demonstrated by the superposable curves obtained after the query; and *interface* defines too an other well separated theme as is demonstrated by its bimodal distribution. Finally, the graph of words gives us an easy way to find the most interesting and reliable statistical correlations. This output permits a quick study of the main hidden relations between words in \mathcal{V} , less apparent on the whole table in the Figure 3 unless we use a color scale for the frequencies or clustering.

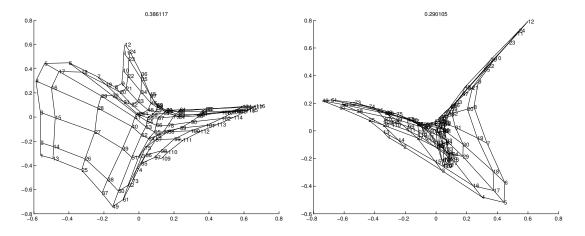


Figure 1: Factorial planes for eigenvectors (1,2) and (2,3). As we stopped before convergence, we get a shape empirically showing the link between CA and CASOM. The values 0.39 and 0.29 are the projected inertia of the corresponding factorial planes. Each knot of the mesh is the class number k.

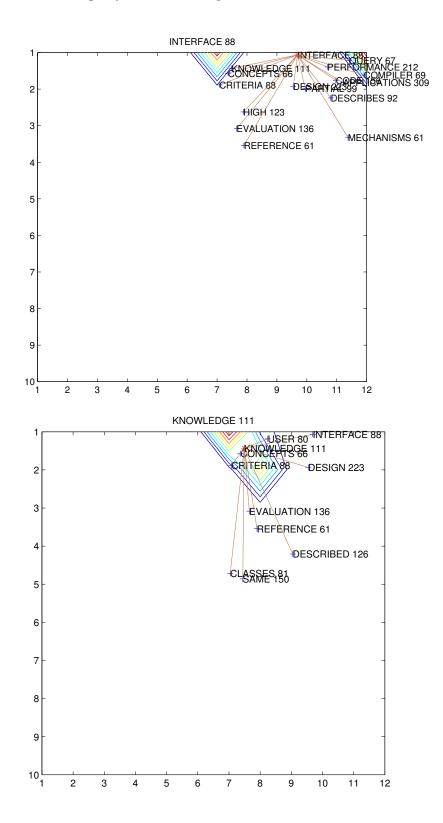


Figure 2: Mean Biplot with graph of words for the two terms *interface*, and *knowledge*. As a remark, every word is written here followed by its total frequency in the corpus. It is shown on the drawings only the restricted graphs of words around the chosen term.

IMAGES	IMAGE	IMAGE	IMAGES	ROBOT	MODELS	KNOWLEDGE	THEIR	MEMORY	DISTRIBUTED	DISTRIBUTED	CODE
IMAGE SEGMENTATION	MATCHING IMAGES	IMAGES BEEN	SPACE DEVELOPED	DYNAMIC SIGNAL	SIMULATION BOTH	CRITERIA CONTROL	DIFFERENT REPORT	SIMULATION SHARED	MEMORY IMPLEMENTATION	APPLICATIONS PERFORMANCE	APPLICATIONS PERFORMANCE
POINTS	IMPORTANT	CLASSIFICATION	OBJECT	SPACE	CONTROL	DESIGN	KNOWLEDGE	PERFORMANCE	PROTOCOL	COMMUNICATION	QUERY
REAL OBJECTS	FEATURES PARAMETERS	DEVELOPED	INFORMATION BOTH	MOTION VISION	DYNAMIC BEEN	METHODS REPORT	CONTROL DESIGN	PARALLEL ARCHITECTURES	APPLICATIONS SHARED	NETWORKS IMPLEMENTATION	APPLICATION
SURFACE	MODELS	CONSTRAINTS PHASE	BEEN	DETECTION	MATRICES	CONCEPTS	USER	ARCHITECTURES	PERFORMANCE	APPLICATION	IMPLEMENTATION DISTRIBUTED
MOTION	REPORT	DIFFERENT	VISION	MODELING	REPORT	THEIR	MAIN	EXECUTION	SIMULATION	PROTOCOL	PROTOCOL
LINES INFORMATION	VISION TOOL	MODELS MORE	TECHNIQUE MORE	CRITERIA TECHNIQUE	MODELING ROBOT	INTERFACE EVALUATION	ARCHITECTURE PRESENTS	DESIGN IMPLEMENTATION	PARALLEL ARCHITECTURE	PROCESS NETWORK	SOFTWARE COMMUNICATION
IMAGES	OBJECT	ESTIMATION	STATISTICAL	DETECTION	BEEN	BEEN	KNOWLEDGE	PARALLEL	DISTRIBUTED	DISTRIBUTED	APPLICATION
CURVES SURFACE	PARTICULAR SHAPE	DIFFERENT SPACE	OTHER REPRESENTATION	HAND MODELS	THEY SIMULATION	KNOWLEDGE PROBLEMS	EACH THEY	MEMORY DISTRIBUTED	PARALLEL MEMORY	APPLICATIONS SOFTWARE	APPLICATIONS LANGUAGE
IMAGE	STRUCTURES	TECHNIQUES	DIFFERENT	PHYSICAL	RESEARCH	MEMORY	INTO	SHARED	PROGRAMMING	COMMUNICATION	MESSAGE
BEEN RESOLUTION	WELL ASSOCIATED	PROPERTIES IMAGE	INFORMATION FUNCTION	OTHER LARGE	SIMULATIONS MANY	STUDIED DESIGN	SAME SEVERAL	EXECUTION MACHINES	ENVIRONMENT DESIGN	APPLICATION PARALLEL	DISTRIBUTED COMMUNICATION
POINTS	OTHER	IMAGES	FINALLY	METHODS	PREVIOUS	TASKS	PARTICULAR	PERFORMANCE	PROGRAMS	PROBLEMS	PROTOCOL
DIFFERENT RECONSTRUCTION	REPORT INFORMATION	BEEN REPORT	APPROACHES BEING	STRATEGY DESCRIBE	STRATEGY PROPOSE	THROUGH ASPECTS	ALLOW MEMORY	LARGE TECHNIQUES	EXECUTION COMMUNICATION	IMPLEMENTATION PROGRAMMING	IMPLEMENTATION DESIGN
CAMERA	LEVEL	STRUCTURE	RESEARCH	STRUCTURES	WHEN	BOTH	PERFORMANCE	IMPLEMENTATION	PROCESSES	REPORT	SUPPORT
IMAGES MOTION	MATRIX GEOMETRY	LEVEL POINT	MODELS DETECTION	HAND OTHER	CLASSIFICATION RELATIONS	BEEN THEY	EXECUTION PROCESSORS	DISTRIBUTED	DISTRIBUTED	DISTRIBUTED IMPLEMENTATION	LANGUAGE ENVIRONMENT
CAMERA	NUMBER	APPROACHES	TECHNIQUE	BOTH	VERY	VERY	SEVERAL	EXECUTION	PROGRAMMING	PARALLEL	SOFTWARE
RECONSTRUCTION IMAGE	IMAGES METHODS	VIEW ESTIMATION	METHODS STRUCTURES	STRUCTURES CLASSIFICATION	THROUGH DYNAMIC	IMPLEMENTATION BECAUSE	EACH PERFORMANCE	PERFORMANCE DETECTION	PROGRAMS PROCESSES	REPORT DYNAMIC	INFORMATION DESIGN
PARAMETERS	DIFFERENT	LINEAR	INFORMATION	LARGE	TREE	DESCRIBE	PARALLEL	PROTOCOL	COMPUTATION	DESIGN	DESIGN DESCRIPTION
SCENE	LINEAR	REPORT	DISCUSS	STATISTICAL	MOST	IMPORTANT	GLOBAL	GLOBAL	SEQUENTIAL	PROGRAM	DEVELOPMENT
POINTS REAL	STATISTICAL REAL	ABLE COMPUTER	LINEAR RANDOM	DESIGN ASPECTS	STRUCTURES CONSTRUCTION	POINT LOCAL	BEEN VERY	CONTROL APPLICATIONS	PRESENTED MECHANISM	CODE LANGUAGES	APPLICATIONS PROVIDES
MATRIX	OBJECTS	OTHER	MOST	EXACT	CONSIDERED	DESIGN	PROCESSOR	THEIR	LANGUAGE	FRAMEWORK	TOOLS
POINTS CAMERA	CONSTRAINTS POINTS	WITHIN IMAGE	NUMBER SEQUENCE	CLASSIFICATION EACH	SPACE NUMBER	WORK BEEN	PARALLEL DISTRIBUTED	DISTRIBUTED LOCAL	PROGRAMS PARALLEL	CONTROL LANGUAGE	LANGUAGE SPECIFICATION
RECONSTRUCTION	POINT	PROBLEMS	LINEAR	ALLOWS	IMPORTANT	PARALLEL	MEMORY	PROCESS	PROGRAM	EXECUTION	SIGNAL
PARAMETERS EQUATIONS	GENERIC GIVEN	NUMBER EFFICIENT	COMPLEXITY SEQUENCES	CLASS MATCHING	CONTEXT VECTOR	NUMBER IMPORTANT	PROCESSORS EXECUTION	THEY EXECUTION	POLICIES DISTRIBUTED	GRAPH IMPLEMENTATION	VERIFICATION ENVIRONMENT
STRUCTURE	BEEN	VISION	ALLOWS	COMPLEXITY	ENVIRONMENT	EVEN	ONLY	PROGRAMS DETECTION	PROPERTIES	REPORT	TOOLS
OTHER MOTION	ALGEBRAIC NUMBER	LEVEL SMALL	TREE EACH	PROPOSE IMPORTANT	SOLUTIONS TECHNIQUE	SEVERAL EACH	WHEN THERE	DETECTION PRESENTED	SEQUENTIAL DIFFERENT	COMPONENTS ARCHITECTURE	FORMAL SYNCHRONOUS
SCENE	WHEN	PROCESSING	PROPOSE	EFFICIENT	MOST	DESIGN	TASK	GLOBAL	REPORT	SOFTWARE	PROGRAMMING
PROPOSED POINTS	DESCRIBE POINTS	DOMAIN SPACE	WHEN METHODS	DIFFERENT NUMBER	BEEN NUMBER	PROCESSING MEMORY	EACH DISTRIBUTED	APPLICATIONS DISTRIBUTED	INTO DISTRIBUTED	RULES VERIFICATION	DESCRIPTION LANGUAGE
CONVEX	SIMPLE	ROBOT	DEGREE	IMPLEMENTATION	THAN	NUMBER	NUMBER	EXECUTION	PROPERTIES	LANGUAGE	PROGRAMMING
LINE GIVEN	GIVEN POINT	POINT RESOLUTION	EXACT COMPUTATION	CLASSIFICATION APPLICATION	ONLY OPTIMAL	PROCESSORS SCHEDULING	MESSAGES SIZE	PROGRAM GLOBAL	CONTROL GRAPH	MECHANISM PROGRAMMING	SPECIFICATION
OBJECTS	SPACE	REPRESENTATION	SEGMENTS	VALUES	VARIABLES	BEEN	STRUCTURE	COMPUTATION	PROGRAM	STRUCTURES	LANGUAGES ABSTRACT
POINT	WHERE ROBOT	LINEAR	IMPLEMENTATION	EACH PROPOSE	BEEN MOST	GENERAL	EXECUTION ONLY	STATE	LEVEL	PARALLEL STATE	OBJECT
PROBLEMS PLANE	EFFICIENT	MOST EFFICIENT	MOST EACH	CONSISTS	CLASSIFICATION	GIVEN ONLY	POSSIBLE	GRAPH GENERAL	COMPUTATION EACH	VARIABLES	SIGNAL SEMANTICS
INITIAL	EXACT	GENERAL	MULTIPLE	COMPLEXITY	SEVERAL	POSSIBLE	PROGRAMS	MESSAGES	DETECTION	EXECUTION	STRUCTURES
NUMBER SURFACE	STRATEGY OPTIMAL	FUNCTIONAL REPRESENTATION	TECHNIQUE POLYNOMIAL	VALUE	SOFTWARE NUMBER	WHEN SCHEDULING	OVER SCHEDULING	PROPERTY SEQUENTIAL	OTHER CONSISTENCY	INPUT GRAPH	APPLICATIONS SEMANTICS
MESH	STRATEGY	DIFFERENT	MORE	LINEAR	COMPLEXITY	TASKS	COMMUNICATION	INTO	GRAPH	FORMALISM	LANGUAGE
PART EXAMPLES	GIVEN FINITE	POLYNOMIAL MORE	THEIR SOLUTIONS	CODE ONLY	PARALLEL MOST	OPTIMAL PARALLEL	TASKS PARALLEL	CONSISTENCY EXECUTION	STATE CLASS	OBJECT PROGRAMMING	PROGRAMMING LANGUAGES
PROPOSED	CONSIDER	COMPUTE	ALGEBRAIC	THEIR	WHERE	PROCESSOR	PROCESSORS	TASKS	SEQUENTIAL	EACH	PROGRAM
APPLICATION SURFACES	CRITERIA CLASS	DETECTION APPROACHES	CLASSICAL PROPOSE	EACH GEOMETRIC	PROBLEMS POLYNOMIAL	COMPLEXITY TASK	CONSIDER GENERAL	CALLED CONTEXT	ONLY CRITERIA	MORE CLASS	ABSTRACT LOGIC
GIVEN	PROGRAM	PARTICULAR	DEGREE	GIVEN	CONSIDER	WHERE	WHERE	STRUCTURE	EACH	LANGUAGES	FUNCTIONAL
MESHES REPORT	PROGRAMS REPORT	VARIOUS POINT	STRUCTURE METHODS	THAN ALLOWS	OBTAIN WILL	WHEN PROBLEMS	CONSTRAINTS TIMES	OPERATIONS REPRESENT	THEORY BEEN	PROGRAM DIFFERENT	NATURAL DYNAMIC
FLOW	GIVEN	MATRIX	MATRIX	COMPLEXITY	ONLY	STRUCTURE	GRAPH	GRAPH	CONTROL	STRUCTURES	SEMANTICS
SHAPE FIELD	APPLICATIONS NUMERICAL	MATRICES ALLOWS	MATRICES POLYNOMIAL	PROBLEMS MATRIX	SIZE NUMBER	OPTIMAL COMMUNICATION	SCHEDULING GENERAL	RULES STRUCTURE	STATE CLASS	PROPERTIES THEIR	PROGRAM LANGUAGE
NUMERICAL	METHODS	DEGREE	PROBLEMS	POLYNOMIAL	POLYNOMIAL	SCHEDULING	GRAPHS	EACH	THEORY	NOTION	PROOF
MESH MESHES	SIMULATION PROBLEMS	METHODS FUNCTIONS	COMPUTING PART	GIVEN MATRICES	TIMES	GRAPH PROCESSOR	NUMBER TREES	OBJECTS PROCEDURE	CALLED GIVEN	CONTEXT ALGEBRAIC	PROPERTIES LANGUAGES
FLOWS	REPORT	APPROXIMATION	METHODS	THEORY	LINEAR	DERIVE	TASKS	GLOBAL	OPTIMAL	SEQUENCES	PROGRAMMING
SIMULATION EQUATIONS	ALLOWS HERE	TERMS POINT	ALGEBRAIC	FORM	GRAPH	POSSIBLE	PARTICULAR	CALLED	GRAPH	FUNCTIONAL	LOGICAL
COMPUTATION			APPLICATIONS			DISTRIBUTION	CONSTRUCTION	DISTRIBUTED	BULES	CIVEN	
	APPLIED	INTO	APPLICATIONS NUMERICAL	ASYMPTOTIC DEVELOPED	NETWORK THEIR	DISTRIBUTION MODELS	CONSTRUCTION GENERATED	DISTRIBUTED TREES	RULES STRUCTURES	GIVEN FUNCTIONS	THEIR LOGIC
NUMERICAL	NUMERICAL	INTO APPROXIMATION	NUMERICAL FUNCTIONS	DEVELOPED PART	THEIR MODELS	MODELS STOCHASTIC	CONSTRUCTION GENERATED TIMES	TREES CONSTRUCTION	STRUCTURES PROPERTIES	FUNCTIONS THEIR	THEIR LOGIC PROOF
NUMERICAL EQUATIONS FLOW	NUMERICAL METHODS TERMS	INTO APPROXIMATION SOLUTION METHODS	NUMERICAL FUNCTIONS METHODS LINEAR	DEVELOPED PART METHODS PROBLEMS	THEIR MODELS ASYMPTOTIC NETWORKS	MODELS STOCHASTIC SIMULATION NETWORKS	CONSTRUCTION GENERATED TIMES TREES DISTRIBUTED	TREES CONSTRUCTION TREE TREES	STRUCTURES PROPERTIES OTHER THOSE	FUNCTIONS THEIR FUNCTIONS PROCESSES	THEIR LOGIC PROOF LOGIC CALCULUS
NUMERICAL EQUATIONS FLOW SOLUTION	NUMERICAL METHODS TERMS WHEN	INTO APPROXIMATION SOLUTION METHODS LINEAR	NUMERICAL FUNCTIONS METHODS LINEAR MODELS	DEVELOPED PART METHODS PROBLEMS DEVELOPED	THEIR MODELS ASYMPTOTIC NETWORKS COMPUTATION	MODELS STOCHASTIC SIMULATION NETWORKS POINT	CONSTRUCTION GENERATED TIMES TREES DISTRIBUTED OPTIMAL	TREES CONSTRUCTION TREE TREES DISTRIBUTED	STRUCTURES PROPERTIES OTHER THOSE DEFINE	FUNCTIONS THEIR FUNCTIONS PROCESSES LANGUAGE	THEIR LOGIC PROOF LOGIC CALCULUS LANGUAGE
NUMERICAL EQUATIONS FLOW SOLUTION DIFFERENT FLOWS	NUMERICAL METHODS TERMS WHEN CONSIDER SOLUTION	INTO APPROXIMATION SOLUTION METHODS LINEAR MATRICES LARGE	NUMERICAL FUNCTIONS METHODS LINEAR MODELS MATRICES STRUCTURES	DEVELOPED PART METHODS PROBLEMS DEVELOPED ASYMPTOTIC FUNCTIONS	THEIR MODELS ASYMPTOTIC NETWORKS COMPUTATION NUMBER THEORY	MODELS STOCHASTIC SIMULATION NETWORKS POINT PROCESSES NUMBER	CONSTRUCTION GENERATED TIMES TREES DISTRIBUTED OPTIMAL PROCESS PROCESSORS	TREES CONSTRUCTION TREE TREES DISTRIBUTED PROCESSES GENERAL	STRUCTURES PROPERTIES OTHER THOSE DEFINE CONSISTENCY PROVE	FUNCTIONS THEIR FUNCTIONS PROCESSES LANGUAGE FORM MAIN	THEIR LOGIC PROOF LOGIC CALCULUS LANGUAGE TERMS THEORY
NUMERICAL EQUATIONS FLOW SOLUTION DIFFERENT FLOWS SIMULATION	NUMERICAL METHODS TERMS WHEN CONSIDER SOLUTION FLOW	INTO APPROXIMATION SOLUTION METHODS LINEAR MATRICES LARGE FIELD	NUMERICAL FUNCTIONS METHODS LINEAR MODELS MATRICES STRUCTURES WORK	DEVELOPED PART METHODS PROBLEMS DEVELOPED ASYMPTOTIC FUNCTIONS WHERE	THEIR MODELS ASYMPTOTIC NETWORKS COMPUTATION NUMBER THEORY STOCHASTIC	MODELS STOCHASTIC SIMULATION NETWORKS POINT PROCESSES NUMBER AVAILABLE	CONSTRUCTION GENERATED TIMES TREES DISTRIBUTED OPTIMAL PROCESS PROCESSORS NUMBER	TREES CONSTRUCTION TREE DISTRIBUTED PROCESSES GENERAL RELATIONS	STRUCTURES PROPERTIES OTHER THOSE DEFINE CONSISTENCY PROVE OBJECTS	FUNCTIONS THEIR FUNCTIONS PROCESSES LANGUAGE FORM MAIN BEHAVIOUR	THEIR LOGIC PROOF LOGIC CALCULUS LANGUAGE TERMS THEORY PROGRAM
NUMERICAL EQUATIONS FLOW SOLUTION DIFFERENT FLOWS	NUMERICAL METHODS TERMS WHEN CONSIDER SOLUTION	INTO APPROXIMATION SOLUTION METHODS LINEAR MATRICES LARGE	NUMERICAL FUNCTIONS METHODS LINEAR MODELS MATRICES STRUCTURES WORK FUNCTION	DEVELOPED PART METHODS PROBLEMS DEVELOPED ASYMPTOTIC FUNCTIONS	THEIR MODELS ASYMPTOTIC NETWORKS COMPUTATION NUMBER THEORY	MODELS STOCHASTIC SIMULATION NETWORKS POINT PROCESSES NUMBER AVAILABLE COMMUNICATION	CONSTRUCTION GENERATED TIMES TREES DISTRIBUTED OPTIMAL PROCESS PROCESSORS	TREES CONSTRUCTION TREE TREES DISTRIBUTED PROCESSES GENERAL	STRUCTURES PROPERTIES OTHER THOSE DEFINE CONSISTENCY PROVE	FUNCTIONS THEIR FUNCTIONS PROCESSES LANGUAGE FORM MAIN	THEIR LOGIC PROOF LOGIC CALCULUS LANGUAGE TERMS THEORY
NUMERICAL EQUATIONS FLOW SOLUTION DIFFERENT FLOWS SIMULATION SCHEMES FINITE PRESENTED	NUMERICAL METHODS TERMS WHEN CONSIDER SOLUTION FLOW SIMULATION NUMBER CONVERGENCE	INTO APPROXIMATION SOLUTION METHODS LINEAR MATRICES LARGE FIELD ILLUSTRATE WHEN TERMS	NUMERICAL FUNCTIONS METHODS LINEAR MODELS MATRICES STRUCTURES WORK FUNCTION CONVERGENCE MANY	DEVELOPED PART METHODS PROBLEMS DEVELOPED ASYMPTOTIC FUNCTIONS WHERE REPORT TIMES THEORY	THEIR MODELS ASYMPTOTIC NETWORKS COMPUTATION NUMBER THEORY STOCHASTIC STRUCTURES REPRESENT PROCESSES	MODELS STOCHASTIC SIMULATION NETWORKS POINT PROCESSES NUMBER AVAILABLE COMMUNICATION DISTRIBUTED WHEN	CONSTRUCTION GENERATED TIMES TREES DISTRIBUTED OPTIMAL PROCESSORS PROCESSORS NUMBER EACH PROCESSOR TASKS	TREES CONSTRUCTION TREE TREES DISTRIBUTED PROCESSES GENERAL RELATIONS EXPLICIT LIKE MEASURES	STRUCTURES PROPERTIES OTHER THOSE DEFINE CONSISTENCY PROVE OBJECTS WHILE THEIR CLASS	FUNCTIONS THEIR FUNCTIONS PROCESSES LANGUAGE FORM MAIN BEHAVIOUR SPECIAL THEREFORE PROPERTIES	THEIR LOGIC PROOF CALCULUS LANGUAGE TERMS THEORY PROGRAM PROPERTIES PROVE RULES
NUMERICAL EQUATIONS FLOW SOLUTION DIFFERENT FLOWS SIMULATION SCHEMES FINITE PRESENTED EQUATIONS	NUMERICAL METHODS TERMS WHEN CONSIDER SOLUTION FLOW SIMULATION NUMBER CONVERGENCE PROBLEMS	INTO APPROXIMATION SOLUTION METHODS LINEAR MATRICES LARGE FIELD ILLUSTRATE WHEN TERMS FUNCTION	NUMERICAL FUNCTIONS METHODS LINEAR MODELS MATRICES STRUCTURES WORK FUNCTION CONVERGENCE MANY FUNCTION	DEVELOPED PART METHODS PROBLEMS DEVELOPED ASYMPTOTIC FUNCTIONS WHERE REPORT TIMES THEORY MEASURES	THEIR MODELS ASYMPTOTIC NETWORKS COMPUTATION NUMBER THEORY STOCHASTIC STRUCTURES REPRESENT PROCESSES MODELS	MODELS STOCHASTIC SIMULATION NETWORKS POINT PROCESSES NUMBER AVAILABLE COMMUNICATION DISTRIBUTED WHEN NETWORKS	CONSTRUCTION GENERATED TIMES TREES DISTRIBUTED OPTIMAL PROCESSORS NUMBER EACH PROCESSOR TASKS GRAPH	TREES CONSTRUCTION TREE DISTRIBUTED PROCESSES GENERAL RELATIONS EXPLICIT LIKE	STRUCTURES PROPERTIES OTHER THOSE DEFINE CONSISTENCY PROVE OBJECTS WHILE THEIR CLASS OPTIMAL	FUNCTIONS THEIR FUNCTIONS PROCESSES LANGUAGE FORM MAIN BEHAVIOUR SPECIAL THEREFORE PROPERTIES NOTION	THEIR LOGIC PROOF CALCULUS LANGUAGE TERMS THEORY PROPERTIES PROVE RULES LANGUAGE
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Figure 3: Table of the multinomial centers for the English summaries : the terms corresponding to the components with the highest probabilities are shown to caracterize associated classes. It appears that close centers often represent similar themes. We can retrieve here the less apparent two areas where the terms *interface*, and *knowledge* were shown to be the most frequent previously.

4 Conclusion

Our work gives new ideas to deal with self-organizing maps. First, we have presented a new self-organizing map method which has strong links with Correspondence Analysis; as CA is intensively used in textual data analysis, our model is an ideal method to scale CA for large textual datasets where matrices are very sparse with the KL distance known to be competitive, and numerically more efficient than the χ^2 one because zero values are cancelled. We have presented some remarkable properties and the first biplot with a SOM algorithm. Second, new ways to evaluate the quality of the final map have also been briefly given, by visual display or by more quantitative methods. To our knowledge, the parallel between multinomial probability vectors and a discrete bivariate law is an original idea in this domain. Finally, the model is illustrated for KD and IR, providing intuitive indicators. Our paper gives new perspectives for self-organizing map methods in the categorical data analysis field. Biplot is a powerful feature which is lacking in most of the currently developed methods. For instance Multidimensional Scaling could be used to make such a biplot, though inevitably losing the understanding of the projections obtained. Our approach gives tools to have an indepth look at a dataset and also to help as a complementary tool to retrieve data by answering a query. Finally, scaling CASOM to bigger datasets is hopefully possible thanks to the SOM experience[20]. Roughly speaking, our maps can be constructed by any classical SOM process on the reducted data matrix with a joint clustering of the frequencies vector or using[21] fuzzy batch quantities to construct multinomial vectors.

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