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Virtual Meeting Analyzer: A Web application to visualize and analyze social networks emerging in group meetings

Alessandro Giuseppe Privitera[1], Francesco Martino[1] and Luciano Gamberini[1]

[1]Human Technology Lab, Department of General Psychology,
University of Padua
(Italy)

ABSTRACT

The possibility to analyze the social network emerging from the relations between people participating in a meeting could improve the effectiveness and satisfaction of the communication that occurs during the meeting. However, it requires accurate recording of direction, source and addressee(s) of all verbal exchanges in a format that allows the application of algorithms to extract and visualize social network indices. Virtual Meeting Analyzer is a Web application developed to overcome any complexity in this process. By using a simple interface and an intuitive input modality, VMA allows users without any specific skill in Social Network Analysis or informatics to track social network relations in small meetings and extract indices either during or after the meeting. The application is divided into four modules: meeting creation, configuration, recording and temporal analysis. This paper describes VMA and the results of a test carried out to evaluate its ease of use.

Keywords: *Virtual Meeting Analyzer, Graph Theory, Social Network Analysis, Visualization.*

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1. Introduction

Every type of social structure can be presented with graphs in which nodes represent social actors (a person, an organization, a nation, a blog and so on) and arcs represent relationships between nodes (Scott, 2000). This formal representation is called a Social Network and gravitates around the relationships between actors, which can be of any type: closeness, friendship, opinion about another person, physical or virtual connection, etc. A classic visualization of Social Network data and indices is the

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* Corresponding Author:
Alessandro Giuseppe Privitera
Human Technology Lab, Department of General Psychology, via Venezia 8, 35131, Padua (Italy)
E-mail: ale.privi@alice.it

one offered in Figure 1, which is composed of dots and lines; several other visualizations are possible, each one having different advantages in clarity and aesthetics (Bender-deMoll & McFarland, 2006; Donath, Karahalios & Viègas, 1999).

Currently, the analysis of social networks is successfully employed to monitor social groups for research purposes or for organizational interventions (e.g., Cross, Borgatti & Parker, 2002; Martino, Baù, Spagnolli & Gamberini 2009; DiMicco & Bender, 2004) by providing them with feedback about the properties of their relational structure.

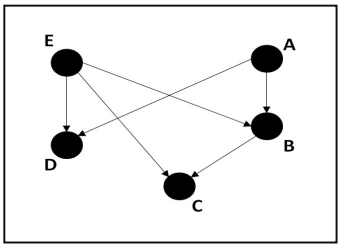

Figure 1. A classic visualization for a graph.

This paper presents Virtual Meeting Analyzer (VMA), a tool that permits the visualization and analysis of small meetings (up to 20–30 participants) in a simple way. The analysis of the interaction in small groups is usually carried out in organizational contexts where no expertise in social network analysis or computer science is available. Sophisticated software for social network analysis (such as Commetrix and Gephi) do not suit these contexts, so that researchers/practitioners typically resort to manually coding the group interactions, a procedure that leaves room for mistakes and inaccuracies. VMA offers a usable interface to support the systematic collection of data that is immediately elaborated by Social Network Analysis (SNA) algorithms and offers analytic reports that are easy to understand. Data entry is very intuitive and requires no coding. It also takes into account the fact that small group meetings are characterized by dynamic changes in their structure over time (Bender-deMoll & McFarland, 2006), since the sampling method considers events as punctual events that are associated with their temporal properties. VMA is a Web application that does not need to be installed on a hard disk and is accessible by any device connected to the Internet or to an Intranet. Finally, VMA is designed to work on a tablet PC with pen input (as well as on a regular PC with a mouse).

In the rest of this paper, first the application rationale and modules are explained, then the method and results to evaluate its ease of use are reported. Future possible upgrades of the application are described in the conclusion.

2. VMA modules

The application is divided into four modules corresponding with the main categories of activities that can be performed with it: meeting creation, configuration, recording and temporal analysis.

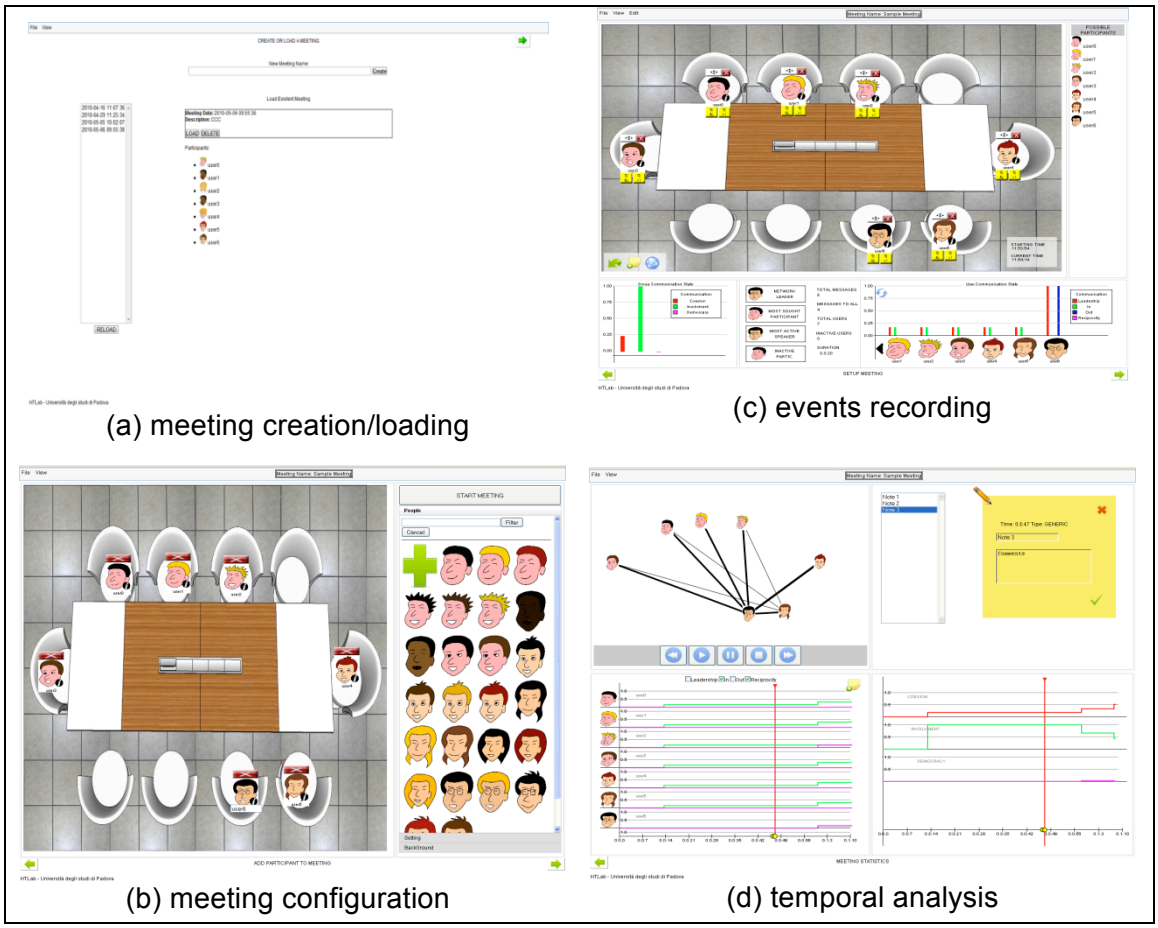

Figure 2. The four modules of Virtual Meeting Analyzer.

2.1 Meeting creation

The first module permits users to create a new virtual meeting or to load a previously created meeting archived in the database. From the page illustrated in Figure 2a, the user can create a meeting, define its creation date and add a short description. From this module it is possible to access basic information from available meetings, such as their date, description and participants.

2.2 Configuration

The second module of VMA permits users to specify the characteristics of the meeting environment (see Figure 2b). It offers several options in order to choose those which are more similar to the actual meeting environment and then facilitate the recording phase. On the left side of the screen, a top view of the virtual room is presented; on the right side of the screen, the icons to select participants, floor texture and table shape by dragging them into the meeting room are available. Name, role and contact info of each participant can also be inserted. Once finished, the user can click on the “start meeting” button and proceed to the next module, which allows one to record the communication events.

2.3 Recording

The third module permits users to record communication events that occur during the meeting and to get instantaneous information on the network. The working area is divided into two parts (Figure 2c). The upper part presents the virtual room and allows users to record the events. Six types of events can be recorded: a person speaking to another person, a person speaking to all, a person speaking to more than one, a person changing his or her seat, a person exiting the room and a person entering the room. These types of events can be recorded either by dragging the avatar’s icon around (i.e., changing seats) or by clicking on a small set of dedicated buttons positioned around the participants’ icon. Every time a communication event is recorded, the arcs from the speaker to the listeners receive a “+1” in weight. When an event is inserted, lines between involved avatars are drawn to convey the idea of the graph of relationships. To avoid reading difficulties related to overlapping arcs, the arcs fade away after a few seconds. It is possible to repopulate the entire graph with the arcs by clicking on a dedicated button.

On the lower part of the screen, the indices about the state of the network calculated in real time are displayed as bar graphs. Considering the type of network involved in this work (i.e., dynamic, directed weighted network with a few actors), the following SNA indices were implemented (technical name is between brackets): Leadership (Centrality Degree), In (Centrality Indegree), Out (Centrality Outdegree), Reciprocity, Involvement (Centralization), Democracy (Group Reciprocity) and Cohesion (Density). The graph on the left shows group indices related to the macroscopic structure of the network (i.e., Centralization, Group Reciprocity and Density); the graph on the right shows individual indices related to the status in the network of single actors (i.e.,

Centrality Degree, Centrality Indegree, Centrality Outdegree and Reciprocity) (Barnes & Hararay, 1983).

Other information offered in this lower area of the screen is the network leader (person with the highest degree), the most sought participant (person with higher indegree), the most active speaker (person with higher outdegree) and the most inactive participants (people with lower reciprocity), the total number of communication events occurred, the duration of the meeting, the number of participants and the number of inactive users.

A particular moment in time can be marked and a note can be inserted that could be useful during the temporal analysis.

2.4 Temporal Analysis

The fourth module offers a temporal description of the development of the network, showing its structure and indices as they evolved over time during the meeting (Figure 2d). The user can receive the temporal analysis of the whole session or set a particular starting time. The upper section of the screen will show the evolution of the social network graph, including the notes inserted by the user in the recording module (which can be modified). The lower section will show the evolution of the indices over time.

3. Development

VMA was implemented as a Web application that can be remotely accessed by virtually any Internet-connected device and to be instantly updated without the need to update every single installation. A Web application is also more appropriate than usual desktop solutions in case collaborative features are to be installed (collaborative features will be developed in future upgrades of the application).

VMA supports a vast number of clients with different features and different input methods (i.e., every device with a modern browser that supports HTML version 5). The client side of the application was developed using HTML (version 5) and JavaScript with AJAX methodologies client-side. The server side of the application, which contains all the implementation of algorithms and data handling, was developed using Python. The application was designed to work on an Apache webserver platform (with mod_python extensions), but it can run on any platform suitable to act as an HTTP

server and Python interpreter. MySQL was chosen as the database management system for meeting data storage and management.

The adjacency matrix of the graph representing the network was inserted as input with a single value (in case of group indices) or a vector of values (one value for each node in case of individual indices) as output. All the indices chosen return a normalized value ($x \in R$, $0 < x < 1$). For the calculation of some indices, the adjacency matrix underwent a process of dichotomization by calculating a pivot value that consisted of the mean value $\neq 0$ contained in cells of the matrix and subsequently changing each value to 0 or 1, respectively, if they are lower or higher than the pivot value.

4. Evaluation

4.1 Objectives

The application is directed to users without any specific technical background and who need to track the communication events while they are in progress. Next, usability represents a crucial dimension of this tool. Once development was completed and after a debugging phase, the ease of use of VMA was evaluated.

The evaluation took place in a laboratory and included two sessions. One session was aimed at comparing different versions of the interface elements to find the easiest one. For several commands, two different visualization options were available in the design phase; therefore, two different versions of the interface were created that included these options. The second session aimed to test the comprehensibility of the recording module by simulating a real usage of the application and comparing two different input modalities; i.e., a pen with a tablet PC or a mouse with a desktop PC.

The sample of the first session was constituted of 13 people (average age: 24.54, SD = 5.09), divided into two subsamples of 7 and 6 people, who were shown one version of the interface each. The second session only involved the first subsample (average age: 25.86, SD = 4.34). The first session included one variable with two levels (i.e., version A and version B of the interface, N = 13); the second session included a different variable with two levels (pen versus mouse input modality, N = 7). Both variables varied between subjects.

4.2 Tools

First session

A checklist was developed for the first session to measure the usability of the various elements present in the two versions of the interface. The checklist consisted of 35 statements with which the user had to express his/her agreement on a 5-point Likert scale. The items investigated five usability dimensions of the interface: learnability, navigability & design, visibility & comprehensibility, error handling, and mapping effectiveness.

Second session

A questionnaire was created for the second session to evaluate the comprehensibility of the information provided by the recording module. The questionnaire was comprised of three main questions regarding the network properties of the analyzed group. Participants were asked to identify which group member was the group leader (they could answer by looking at the leadership index values or at the leader icons); which group member spoke less (they could answer by looking at the outdegree index) and which group members were interacted with the most (they could answer by looking at the reciprocity index). For each question, participants were also asked to explain upon which feature they relied to create their answer and whether the information provided by the application was coherent with the impression they had during the task. A final set of items asked to report the number of events observed and whether the statistics were understandable and useful (rates were collected on a 5- point scale).

4.3 Procedure

First session

The first session started with participants' signature on an informed consent form and a training phase, during which the participants saw a 5-minute tutorial about the functioning of the application and then tried to use the application by themselves for 5 minutes. Once the training phase was completed, version A or B of the interface was presented to the user. The monitor then showed the first request; after the user read it and decided to go on with the fulfillment of the request by pressing the 'ok' button, a timer started. Each task had a predefined time limit that was unknown to the participant. Once the time elapsed, the application automatically showed the

subsequent request. If the task was not accomplished by that time, it was considered as having failed. There were five requests:

1. Creating a new meeting;
2. Positioning four participants around the table;
3. Starting the events recording module;
4. Reporting six types of communication events;
5. Setting the time marker of a timeline on the first minute of the meeting and inserting a new note.

This evaluation session was run on a Tobii 1750 apparatus, allowing researchers to record the users' eyes' fixation on a particular screen area. After the last request, the participant was asked to fill in the usability checklist.

The measures collected during this session were success in completing the five tasks, the length of eye fixation on the screen, and the answers to the checklist.

Second session

The participants sat in front of a wall on which a video clip was projected that showed a few-minute interview with a music band; participants were asked to use VMA to track the communication events occurring in the group discussion. They were given either a desktop PC with a mouse or a tablet PC with a pen. As the video clip ended, participants were asked to fill in the comprehension questionnaire.

4.4 Data

The data collected for the evaluation included:

- Answers to the usability checklist;
- Number of tasks completed with success;
- Length of fixations;
- Answers to comprehension questionnaire.

5. Results

5.1 Usability checklist

The answers to the checklist (Table 4) show that the logic sequence followed by the software is considered well-planned in both versions of the interface. The interface seemed to be free of errors and bugs, and the mapping of the real meeting onto the

virtual one was judged to be good. The tutorial was considered useful and the controls were easy to recall. Regarding the difference between the two versions of the interface, the mean value of all items was 3.72 for Version A (SD=0.70) and 4.07 for Version B (SD=0.67). Considering single items in the checklist, the answers in the two versions differed significantly only in item 10 (where Version B received a better evaluation). In version A, users reported a problem in the timeline navigation in the temporal analysis module (Item 22, Version A, reported a negative score) coherently with the task results (see 5.2), since sending a note had a high failure rate.

5.2 Task completion

Table 1 reports the percentage with which each task was successfully completed. A lower failure rate was observed in the second version of the software; in particular, in the temporal analysis module (Timeline positioning). This part of the interface is planned to be redefined in a future version of the application. However, data distributions are highly correlated (Pearson p=0.907).

Task Type	**Version A**	**Version B**
Meeting Creation	100%	100%
Participants Positioning	100%	100%
Start of Recording	91%	85%
Events Registration	86%	98%
Timeline positioning	43%	69%

Table 1. Task success rate.

5.3 Fixation length and number

A third comparison between versions A and B of the interface was based on the length of eye fixation on specific areas of the screen (Table 2). These areas had the same extension in both versions of the software. In tasks 1 and task 2, users spent less time fixating upon useful areas in version A than in version B.

Task Type	**Version A**		**Version B**	
	Total time spent in useful areas	*Total time spent in useless areas*	*Total time spent in useful areas*	*Total time spent in useless areas*
Meeting Creation	2937	6113	3220	5327

Participant Insertion	9389	56411	19944	51980
Start Recording	951	1723	877	3464
Event Recording	39807	59692	75996	44642
Note Modifying	1977	16050	2951	14997

Table 2. Eye fixation time (ms) on tasks.

5.4 Comprehension

Overall, this analysis shows that participants correctly understood the meaning of the indices, which were also meaningful and robust to variations (See Table 3). Questions are correctly answered using the appropriate index or by inference from other indices. Regarding the respondents' opinion about the usefulness of the tool (Table 5), scores were generally positive.

Regarding the difference between tablet and PC, participants who performed the second part of test with the tablet also found the tool significantly more useful than the others. This can be attributed to the use of a non-conventional platform, which users could have found per se more entertaining (Fogg & Tseng, 1999).

Question	**Correct answers**	**Correct source**
Who is the leader of the network?	100%	100%
Who spoke less?	70%	70%
Who were the 2 people who interacted the most?	80%	85%

Table 3. Percentage of correct answers to comprehension questionnaire.

6. Future upgrades

Based on the feedback obtained by the evaluation process described here, a new version of the application is under development to enhance avatar creation, index presentation and temporal development, as well as to support collaboration between users. An interesting field in which this tool could be applied is the analysis of a small group of websites; for example, company websites of a holding to identify the links between websites and visualize whether the website, homepages, contact pages, etc.

are well connected in the network. The main problem of this application is the development of an efficient web-crawler that is modular enough to be installed on a webserver. At the moment an alpha version is being developed.

Item	***Version A***		***Version B***			
	Mean	**SD**	**Mean**	**SD**	**F**	**Sig.**
1. Tutorial instructions were clear.	2.78	0.07	4.25	0.00	0.58	0.46
2. Tutorial was enough to begin using the application.	3.00	0.05	4.25	0.00	1.13	0.31
3. I remember how to create a working session.	4.33	0.05	5.00	0.00	2.00	0.19
4. I remember how to insert users in the working area.	4.67	0.00	5.00	0.00	1.23	0.29
5. I remember how to assign names to users.	4.78	0.05	5.00	0.00	0.60	0.45
6. I remember how to start event recording.	4.00	0.06	4.75	0.03	2.12	0.17
7. I remember how to record communication between A and B.	4.56	0.04	5.00	0.00	1.06	0.33
8. I remember how to record communication from A to many.	4.56	0.06	4.50	1.00	0.04	0.85
9. I remember how to record communication from A to all.	4.56	0.06	5.00	0.00	0.60	0.45
10. I found the colors pleasant.*	3.22	0.05	4.00	0.06	5.54	0.04
11. Graphical elements helped me work in the environment.	3.33	0.06	4.00	0.00	0.48	0.50
12. Graphics were professional.	3.67	0.05	2.75	0.00	0.24	0.64
13. First module components are correctly placed.	4.11	0.05	4.25	0.00	0.03	0.86
14. Second module components are correctly placed.	4.11	0.00	4.50	0.00	0.63	0.45
15. Third module components are correctly placed.	4.11	0.06	3.75	0.07	0.37	0.56
16. Dimensions of conversation recording buttons are adequate.	3.56	0.06	4.25	0.03	0.34	0.57
17. Dimension of other buttons is adequate.	3.67	0.05	3.75	0.00	0.16	0.70
18. It is easy to move avatar icons.	4.67	0.05	4.75	0.00	0.22	0.65
19. It is easy to add new participants.	4.67	0.00	4.50	1.00	0.00	0.95
20. It is easy to add a note.	2.78	0.07	3.00	0.06	0.32	0.59
21. It is easy to modify note contents.	3.67	0.07	3.50	0.04	2.42	0.15
22. Timeline navigation is easy.	2.33	0.05	4.25	0.00	3.66	0.08
23. I know where to click to execute a particular action.	3.44	0.06	4.00	0.00	0.45	0.52

24. Button names were adequate.	3.44	0.05	3.75	0.07	0.03	0.88
25. Navigation buttons are correctly placed.	3.67	0.06	4.00	0.06	1.12	0.31
26. I received a correct feedback after using drawing commands.	3.44	0.04	4.00	0.06	3.41	0.09
27. Effects of my action on the software were visible.	4.22	0.07	4.25	0.07	0.01	0.93
28. It was easy to identify meeting participants.	4.00	0.05	4.50	0.04	0.42	0.53
29. Interface led me to make mistakes.	2.33	1.00	2.50	1.00	1.59	0.23
30. Interface permitted me to correct mistakes.	3.44	0.05	4.00	0.06	1.11	0.31
31. Button disposition led me to make mistakes.	2.00	0.05	2.25	0.06	0.09	0.77
32. Errors compromised the final result.	2.05	0.07	2.25	0.00	0.06	0.81
33. Drawn conversations are real.	3.78	0.05	4.00	0.00	0.03	0.88
34. Conversation represented by the software is similar to the real one.	3.89	0.06	4.00	0.00	0.08	0.79
35. Interface is effective in describing the meeting.	4.11	0.06	4.00	0.00	0.08	0.79

Table 4. Checklist results for the different versions of the software and ANOVA comparisons between version A and version B.

	Tablet PC		PC with Mouse		ANOVA	
	Mean	SD	Mean	SD	F	Sig
1.Perceived consistency of leadership index	4.33	.89	4.25	.58	.83	.38
2.Perceived consistency of outdegree index	4.17	.79	4.75	1.0	.96	.35
3.Perceived consistency of reciprocity index	4.17	.75	4.75	.28	.59	.46
4.Perceived usefulness of VMA information	4,33	.89	3,00	.57	.40	.54
5.Perceived comprehensibility and usefulness of VMA information	3,83	.97	3,50	0	.98	.03

Table 5. Users' opinion of VMA (on a 5-point Likert scale).

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