Human Sensory Assessment Linked with Geo- and Mobile-Data Processing Methods in Urban Planning Exemplified on Different Cultures in Germany and Egypt

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1. Abstract

Human sensory assessment is a new approach to objectively gather subjective data concerning humans' perception of space and emotional reactions towards space in real-time. The resulting data enables urban planners to get a more comprehensive view of interdependencies between people and their urban environment. This paper shows the methodical framework beginning from gathering over processing and analyzing to visualizing emotional reactions of selected participants. The research aims to optimize and automatize the processing between human sensory assessment, geo- and mobile-data. The challenge lies in joining and processing the generated various data types to gain visual tangible results. In order to apply the complete methodical repertoire, different case studies and exemplary analyses were conducted in Germany and Egypt, dealing with the exemplary

research question “How do people of different cultures perceive their environment in different countries?”

2. Introduction

For urban planners, it is important to understand which effects urban environments have on its inhabitants. This is especially important for identifying locations which raise either positive or negative emotions in order to gain helpful insights for urban planning approaches. This information is generally gathered by questionnaires from the citizens. Questionnaires have the restriction that only certain events are reflected. New technologies and methods like sensor technologies and human sensory assessment provide new opportunities to collect subjective data in real-time. Linked with geo positions, subjective data can be led back to specific urban surroundings.

The research at hand treats the handling of new technologies of human sensory assessment linked with geo- and mobile-data in a methodical framework. The research project was conducted in a German-Egyptian collaboration of the University of Kaiserslautern, Germany and the University of Alexandria, Egypt.

3. Goal of the Research

Goal of this research is the improvement of qualitative and quantitative test methods regarding human sensory assessment. It concerns the availability of technical solutions for a better and faster retrospective analysis of individual test runs in order to identify emotional reaction patterns in an urban environment. The exemplary scientific question addresses the possibility to identify indications of various measured emotions of test participants from different countries with differing cultural backgrounds. The physiological changes of participants were measured once in their native environment and then in a foreign/unknown environment.

4. State of the Art

Research on using human sensory assessment methods in urban planning to identify “points of (negative) emotions” was already conducted by several research groups, starting with the “Mental Maps” by Kevin Lynch in his “Image of the city” (Lynch 1960), where participants sketched a map out of their mind of the investigated city. Yet critics claim this technique needed drawing skills to produce the map. Results of tracking people with the help of GPS technology were delivered by Phillips et al. (2001) and by Elgethum et al. (2003). The approach to digitally map feelings like fear in a city was introduced by Sorin Matei. In his “Mental Maps Concept”, he visualized for the first time feelings on a map and created a dimensional VRML (Virtual Reality Modeling Language) model for a better understanding of the environment in the city of Los Angeles (Matei et al. 2001). Unfortunately, he gave his approach the similar technical term “mental map” like Lynch. The difference is that Lynch created maps “out of the mind” and Matei made “emotional maps”.

As a result of the developments in the last years, from “ubiquitous computing” towards ”pervasive sensing” (Martino et al. 2010), two-way connected sensors generate data sets which are produced by volunteers and relevant for spatial planning. Accordingly, citizens are more and more integrated in these networks of applications by using new mobile technologies. Goodchild (2007) refers to this phenomenon as "Citizens as Sensors". Other authors use the term “People-Centric Urban Sensing” (Lane et al. 2006, Campbell et al. 2006) or simply “urban sensing” (Cuff et al. 2008). Citizens that want to be integrated in a planning process could now produce and deliver data, and thus are more in the focus of planning considerations. They act as active sensors for the urban environment. Based on the development of mobile communication techniques, Mark Weiser’s vision of “ubiquitous computing” comes true (Weiser 1991). This contextual shift, described as “urban sensing”, could be a trigger for a “fundamental transition from science and engineering into the realms of politics, aesthetics, interpretation, and motivation” (Cuff et al. 2008 p 1). The first one who combined emotional data with the help of physiological parameters (skin resistance level) and GPS data was Christian Nold in his art project Biomapping (Nold 2008 and 2009). Other examples for collecting “human sensor data” in cities were provided by the MIT Senseable City Lab (Martino et al. 2010 and Resch et al. 2011).

To sum up, the trends described above, like the use of Internet in combination with georeferenced data and ubiquitous mobile computers, are often designated computer systems which can be described as the next evolutionary step of the Internet, the “Geoweb” or “Web 3.0” (The Economist 2007, Batty et al. 2010). Characteristic features and peculiarities of the Geoweb are “the development and changing nature of map-based data mash-ups” and the explanation of “the basic concepts behind map mash-ups, how geospatial data gathering and analysis has changed and how new technologies and standards are impacting on this" (Batty et al. 2010 p 1089).

With the help of the human sensory assessment, a practicable method was applied to identify stress reactions related to physical locations (Zeile et al. 2009, Bergner 2010, Zeile et al. 2011 and Exner et al. 2012). The experimental research consistently shows that emotional reactions are associated with changes in specific physiological parameters, such as skin conductivity and skin temperature, resulting from the activity of the autonomic nervous system (Kreibig 2010). In several projects, the method, the analysis and the workflow have been improved (Taha et al. 2012), especially for a faster workflow or tailoring to a specific target group (Bergner and Zeile 2012). However, the analysis is still to a large part manually carried out. One aim of the project at hand was to speed up the workflow by the implementation of automated analyses.

5. Methodology

Human sensory assessment is based on the usage of body sensors for measuring human physiological data (e.g. skin conductivity and skin temperature) in real-time. Besides the physical activity, reasons for physiological changes are found in psychological processes (Kreibig 2010). In this case, the trigger for these changes is a human's emotion in context of their current environment. In the chosen case studies at hand, the sensor wristband "BMS Smartband" (Bodymonitor Systeme 2013) was used. The wristband records physiological data in a TXT file, which can be analyzed in a further step for emotion stress patterns. For the general comparison of the conducted test runs and the collected emotion data of the participants, the analysis is done with the statistical indicators "average time span between stress reactions" and "average duration of stress reactions". With the help of these indicators, the difference of individual test people in a defined urban area can be figured out in a statistical approach.

For the identification of the original triggers of stress in chosen urban areas, a closer look at the individual runs is essential. Therefore, it was necessary to create a new workflow of analyzing the corresponding video files, in which all the tracks were recorded in the visual field of the respective participant. The synchronization of the resulting emotion data with geo positions via mobile GPS trackers is obligatory. The participants were also equipped with neck cameras to link the generated emotion data with the perceived environment.

In past studies, the transformation of raw physiological data to resulting emotion data (linked with geo position) was a time intensive and not fully automated process. Combining different processing steps in a defined workflow, and especially the reduction of complexity regarding the exchange of data between different software components, was an elementary success of the project. Furthermore, whole data sets can now directly be linked with individual video data of the participants to separate identified emotion sequences. A qualitative analysis of the trigger for specific emotions can conveniently be conducted afterwards for every participant. Finally with the resulting data, it is possible to generate heat maps that visualize identified stress hot spots in urban spaces.

The data processing was mainly realized using Perl scripts that can be applied on any common operating system to provide the flexibility to also allow a web-based processing of data in the future. Perl is a general-purpose, interpreted programming language that offers powerful means to analyze and manipulate data, especially by means of regular expressions. Using this as basis, the tools can be developed quickly and if there are adaptation requests the changes can be managed in situ.

A Perl script was developed for the individual retrospective video analysis that offers the following features: (1) Automatically synchronizing of datasets from GPS-Tracker, camera and Smartband, and (2) Identification of the stress points of the track, and automatic extraction of video snippets of the corresponding time. After that, the identified stress points are stored in a geo-database and visualized. The last step is to aggregate all the individual stress points to a so called “stress hotspot heatmap”, in which all the individual stress spots were combined by a point density analysis (similar to RADAR Sensing, compare Zeile et al. 2012). Some of these tasks could be realized using the RADAR platform (Memmel and Groß 2011), which is based on the ALOE framework (Memmel and Schirru 2007).

To merge all the different data channels, the data has to be synchronized on a one second basis. In case there are unwanted time gaps in the data provided by the GPS tracker, a further preprocessing step can be conducted by applying the “GPS Interpolation” script. Using the generated CSV as an input, this script automatically interpolates missing data by taking into account the last and next known position and timestamp of an identified gap.

Once the data is correctly aggregated, the “StressPhaseIdentifier” can be applied to identify stress phases based on a previous conducted analysis on changes of humans’ physiological data. The script provides an enhanced CSV-file with information about the stress phases, a short overview of all identified stress phases, and statistical information such as the average length of a phase. In addition, the script can also automatically extract corresponding video snippets. In this case, an offset has to be specified to match the timestamps of GPS and video data. The extraction of snippets was realized using the ffmpeg library that is available on any common UNIX-based system. These sequences can be used for the identification of the original triggers of stress in chosen urban areas by a visual comparison with the videos and the measurement results. As a result, it is possible to synchronize skin conductance, stress responses with GPS and the video signal. After that, the visual detection of individual impacts on stress - like bad road surface, orientation problems - is possible (compare Exner et al. 2012) and will be elaborated in further research. Finally, the file with identified stress phases can be used as input for the “GenerateHeatmapInput”-component that will automatically generate a JSON representation usable as input for the generation of heatmaps within the RADAR system (Figure 1).

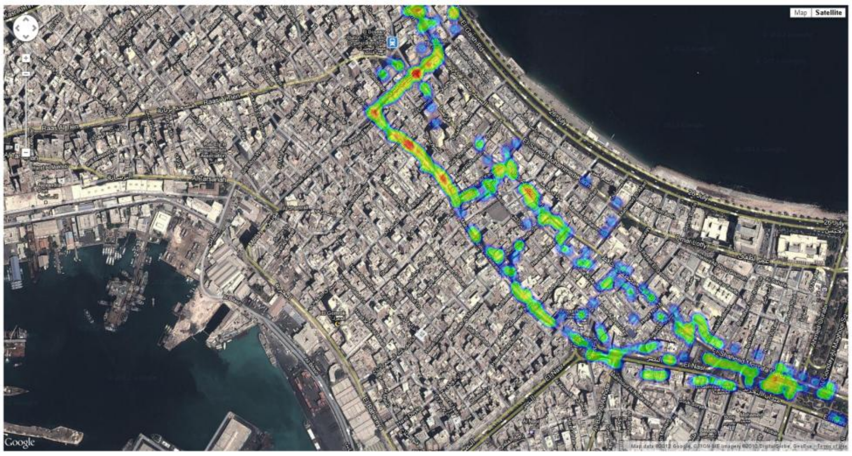

Fig 1: Heatmap of aggregated stress reactions, Alexandria - Egypt

The methodology is to be examined by several test runs in chosen case studies with the same settings, carried out both in the southwest of Germany and in Alexandria. For the test runs the participants were equipped with a Smartband, a GPS tracker and a video camera.

6. The Project

The considered case studies aim to demonstrate the presented methodology and exemplary compare measurements of human sensory assessment in two different urban environments. Examination objects are two representative urban areas in each country - local markets and routes with architectural highlights. The comparative analysis involves the German cities Mannheim and Kaiserslautern and the Egyptian City of Alexandria. Mannheim and Kaiserslautern are two cities in the southwest of Germany. Alexandria is situated at the Egyptian-Mediterranean coast and is after Cairo Egypt's second largest metropolis with more than 4 Million inhabitants. It is assumed, that the different conditions in the urban environments are likely to cause different emotional reactions of the participants. Throughout the studies, each participant was equipped with one video camera, one GPS tracker as well as one Smartband.

6.1. Local Markets

Local markets are very special and unique environments. From an architectural-historical point of perspective, markets are often considered as melting pots of the urban life and reflect the soul and culture of their cities. Markets are often crowded and sometimes noisy. Therefore, they generate a lot of external influences on the citizens.

The local market in Mannheim and the Al Midan local market in Alexandria were selected as test areas for the first study. This study aims at recording the human experience within the two markets, both for locals as well as for foreigners to monitor if and how their reactions might differ in both situations.

6.1.1. Mannheim Local Market

Mannheim local market ("Mannheimer Wochenmarkt") is the oldest and most important market in Mannheim; it is a weekly market which is situated on the main city square in front of the city hall. Merchants are spread out over a rectangular area of 50 m * 85 m (Figure 2).
The testing experiment took place on Tuesday, October 9th 2012 around 1:30 pm. The participants started at the south end of the market and ended almost 15 minutes later at the same point. There was no fixed route given to the participants. Every participant took a separate route. A group of four persons participated in this test: Two Egyptian females and two German males. The participants were asked to take a walk through the market, each on his/her own.

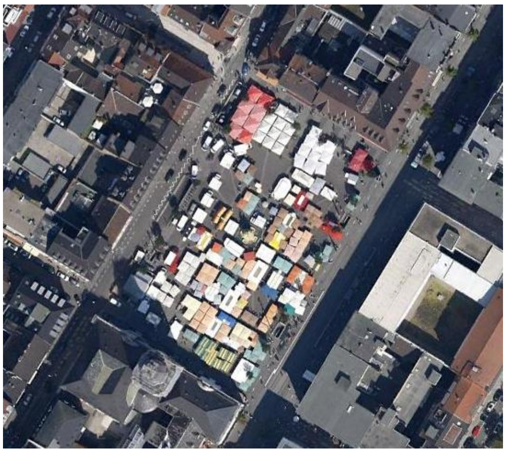

Fig. 2: Mannheim Local Market, Germany (Google Maps, 2013)

6.1.2. Al Midan Local Market

Al Midan local market lies on both sides of a 600m long street located in the old Turkish Town in Alexandria (Figures 3). It is one of the oldest and most frequently visited markets in the city. In contrast to Mannheim it is a street market. It mainly serves adjacent neighborhoods. However, buyers from the whole city target this market for some specialized shops. The main merchandise there is food-related.

This experiment took place on Tuesday, November 20th 2012 around 2:00 pm. It started at the north end of the market (green node) and ended almost 15 minutes later at the south end (blue note). A group of six persons participated in this tests: Two Egyptian females and four German males. The route through the street was fixed and the participants were asked to separately take a walk along the market.

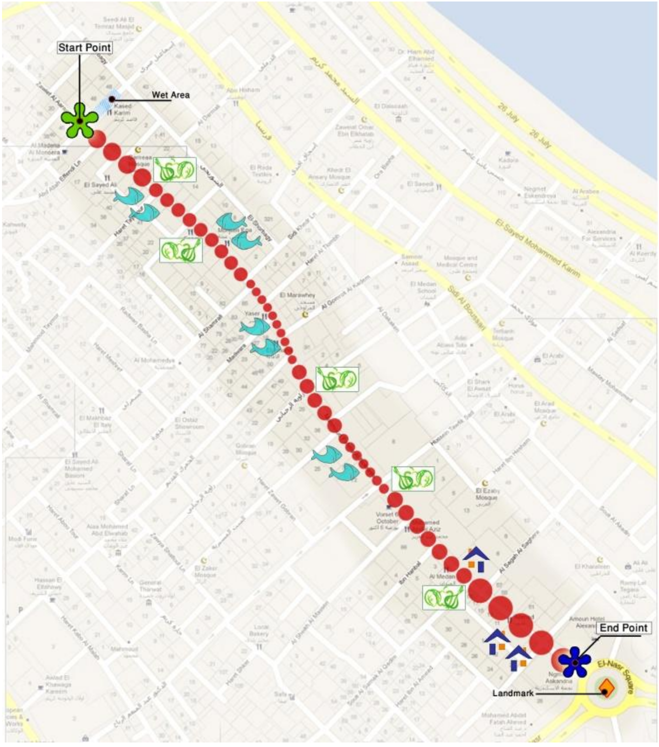

Fig. 3: Al Midan Local Market, Alexandria – Egypt

6.2. Building Culture and Architectural Heritage

Building culture is a very characteristic attribute of cities and reflects architectural and historical heritage. In many cities, especially the ones with historical backgrounds, there are maps for visitors with given routes to discover the multiple highlights and faces of a city. These maps are usually prepared by specialists of the city domain. The question is how the visitors experience their urban environment if they follow the given maps. A potential future field of application is the optimization of more appropriate city maps.

Two tests were carried out, one in the City of Kaiserslautern and a second one in the Turkish Town of Alexandria. In both cases, a group of foreigners was asked to pass by a certain number of city attraction points, first in the order they prefer, later in a pre-set order. The tourists' experiences within each city were recorded to be able to evaluate the pre-set route and to propose the route that more suits the visitors' needs.

6.2.1. Kaiserslautern City Centre

The City of Kaiserslautern's architectural culture is characterized by an old, small medieval city centre where just a few original buildings remain. The rest of the city centre is dominated by the reconstructions of architecture after the Second World War. The experiment took place in the inner city area on two days. On both days and in both tests, two female foreigners were handed a city map, , where the highlights of the City of Kaiserslautern were marked. These were for example the city hall or the Fruchthalle. They were asked to pass by all 14 mandatory points of interest (POI) with additional two optional points. The first test took place on Monday, October 8th around 11:00 am. They started their city tour 30 minutes apart from each other.

Fig 4: Highlights of the City of Kaiserslautern, Germany (With pre-set path)

The second test took place on Thursday, October 11th around 11:00 am. Again, each participant was handed a map, where the highlights of the City were marked, but this time in a pre-set route (Figure 4). Each participant was asked to pass by all 14 mandatory POI, and it was up to her to pass by the two optional ones.

6.2.2. Alexandria City Centre

The route in Alexandria took place in the district called "Turkish Town". A pre-set tour with touristic highlights (Suggested by Alex Med, The Alexandria & Mediterranean Research Center) was examined. This route crossed one of the oldest districts of the modern city (post 1805). It travels through old mosques, bazaars and other listed properties on Alexandria's Heritage list. Similar to the experiment in Kaiserslautern, this one was designed for two days. The four male foreign participants started their city tour ten minutes apart from each other.

Fig 5: Highlights of the Turkish Town, Alexandria – Egypt

The first test took place on Saturday, November 17th around noon. Each participant was equipped with a map, where 22 highlights of the Turkish Town were marked. They were instructed to pass by all mandatory POIs, with the possibility to visit the optional ones. The second test took place on Tuesday, November 20th around 11:00 am. Again, each participant was equipped with map (Figure 5), on which the highlights of the Turkish Town were marked, but this time in a pre-set route to visit the mandatory POIs with the possibility to pass the optional ones.

6.3. Results

The following analyses and their results are exemplary and only show possible indications for the selected groups of participants. They are not representative, because of the small number of participants.

First are presented the results of the case studies at the two markets in Mannheim and Alexandria (table 1 and 2). In these studies, both parties of Germans and Egyptians took part in order to compare the results of the stress analysis directly at the same location and time. The analyzed statistical indicators are the average duration of stress reactions (in seconds) and the average time span between stress reactions (also in seconds). While the Egyptian participants happened to experience longer stress reactions than the German participants (e.g. 5.88 sec. to 5.39 sec.), the German participants have stress reactions more frequently. In the case of the market study in Mannheim, the German participants have a stress reaction every 20.95 seconds, the Egyptian participants in contrast every 22.76 seconds. The same pattern is found at the market study in Alexandria. The results here are more clear. The stress reactions of the Egyptians are about 1.6 seconds longer than the comparison group; the time span between the reactions is on the other hand about six seconds longer until a new stress reaction occurs (see table 2).

Table 1: Stress analysis indicators at the Market Mannheim – Germany

	German participants (n=2)	Egypt participants (n=2)
Average duration of stress reactions (in sec.)	5.39	5.88
Average time span between stress reactions (in sec.)	20.95	22.76

Table 2: Stress analysis indicators at the Market Alexandria – Egypt

	German participants (n=4)	Egypt participants (n=2)
Average duration of stress reactions (in sec.)	4.91	6.57
Average time span between stress reactions (in sec.)	22.21	27.27

The two case studies dealing with the building culture and architectural heritage show a similar outcome (table 3). In these studies the pre-set routes were passed either only by the German participants (in Alexandria) or the Egyptian participants (in Kaiserslautern). The average duration of stress reactions was about one second shorter for the German participants in comparison to the Egyptians. In contrast the Egyptian participants were not stressed as often.

Table 3: Stress analysis indicators at the building culture & architectural heritage pre-set route

	German participants in Alexandria (n=4)	Egypt participants in Kaiserslautern (n=2)
Average duration of stress reactions (in sec.)	4.88	5.82
Average time span between stress reactions (in sec.)	21.34	24.56

In general, the number of participants is not high enough for a resilient scientific outcome and also other effects like age or gender were not taken into consideration. The testing, though, is suitable to show exemplary analyses, which makes it possible to discuss the indicators and the relevance of stress triggers.

Actually, the given case studies show the same indications that the German and Egyptian participants react the same way to their surroundings, whether they are in their home country or not. There is also no difference seen in the quality of their actual surrounding. They perceive their environment in the same way in a dense crowd (at the markets) as well as in other urban spaces (building culture and architectural heritage route). The results of a much larger testing group, though, could imply specific differences.

To define the triggers for the experienced stress reactions, a more qualitative analysis has to be carried out. This can be achieved when all the stress reactions of a singular participant are geo-referenced and visualized on a map (Figure 6). Synchronizing this data with the video material, one can analyze if the triggers of the stress reactions are in context with determined factors in the perception of the surroundings.

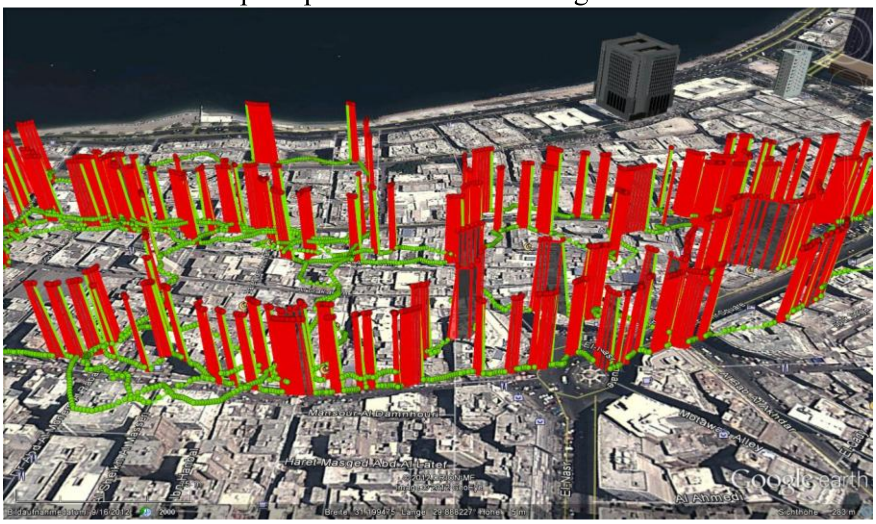

Fig. 6: Visualization of Individual Stress Reactions, Alexandria – Egypt

Furthermore, the stress reactions of all participants can be aggregated in a heat map (Figure 7). In specific areas there is a higher density of stress reactions (red color) than in other areas (blue and green color). With a larger number of participants and an additional analysis of the urban environment, more valid statements can be expressed, if the triggers are connected to the experienced urban space.


Fig. 7: Heatmap of Agglomerated Stress Reactions, Alexandria - Egypt

7. Conclusion and Future Research

The presented data processing methods using human sensory assessment, geo- and mobile-data were made more efficient and partly automated during the research project. Now, it is not only much easier and more time-saving to synchronize and process the different data types, but also a higher amount of data and cases can be handled.

At this point the authors emphasize that the studies are case studies to test the complete methodical approach. The number of participants is too small for valid statistical statements. An expected significance in the results of the given groups of participants from Germany and Egypt is not evident. Besides the mentioned restrictions concerning the resilience of the gathered data, the results indicate that the German and Egyptian participants experienced space the same way regardless to the country they were in. The German participants had shorter stress reactions than the Egyptian participants, but the frequency of stress reactions with the German participants was slightly higher. To achieve more definite and valid statements about the emotional perception of space, a larger number of participants is needed. The presented indicators of stress duration and time span between stress reactions are a possible approach to get statistical statements about a defined urban space from the point of view of the participants. To increase the validity of the indicators, control situations that are non-stressful are planned for in future projects for a better interpretation of the gathered data.

The next step in research will be the combination of the fields human sensory assessment and CAVE-Technologies (Cave Automatic Virtual Environment - Technologies) for an objective verification of the gathered data and for an exclusion of impacts like barking dogs or ringing mobile phones. Users can navigate through the spaces in real-time in a virtual tour. With this setting, it might be possible for the first time to create an urban environment in which the user only reacts to the (virtual) built environment. This means a laboratory situation free of external influences will be created. As a conclusion, the presented method repertoire has a high chance to become an important component for urban planning and sociological analysis in space. By gathering and visualizing objectively measured subjective data in real-time, planners are given tools for a more comprehensive view of interdependencies between people and their urban environment.

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