Examining Government-Citizen Interactions on Twitter using Visual and Sentiment Analysis

Rocío B. Hubert
ICIC CONICET-UNS, Universidad Nacional del Sur,
Bahia Blanca, Argentina
E-mail: rocio.hubert@cs.uns.edu.ar

Elsa Estevez
ICIC CONICET-UNS, Universidad Nacional del Sur,
Bahia Blanca, Argentina
E-mail: ece@cs.uns.edu.ar

Ana Maguitman
ICIC CONICET-UNS, Universidad Nacional del Sur
Bahia Blanca, Argentina
E-mail: agm@cs.uns.edu.ar

Tomasz Janowski
Gdańsk University of Technology, Poland
Danube University Krems, Austria
E-mail: tomasz.janowski@pg.edu.pl

ABSTRACT
The goal of this paper is to propose a methodology comprising a range of visualization techniques to analyze the interactions between government and citizens on the issues of public concern taking place on Twitter, mainly through the official government or ministry accounts. The methodology addresses: 1) the level of government activity in different countries and sectors; 2) the topics that are addressed through such activities; 3) the resources shared between government and citizens as part of interactions; 4) the intensity of citizen response to government announcements; 5) the sentiment expressed by citizens when providing such responses; and 6) the combinations of such issues. Example combinations include identifying topics that generated the largest Twitter activity by government but received the least interest from citizens, identifying topics that generated the most polarized reactions from citizens, or determining correlation between policy announcements and trust, fear and other negative emotions expressed by citizens. The methodology uses visual analytics to reveal patterns and trends associated with various questions, complemented with sentiment analysis to study government-citizen interactions on Twitter. The methodology is validated by examining Twitter presence in five sectors – health, social development, education, environment and work, in five Latin American countries with mature e-Participation capabilities – Argentina, Chile, Colombia, Mexico and Uruguay.

CCS Concepts
• Information systems ~ Social networking sites
• Applied computing ~ E-government
• Visualization ~ Visual analytics
• Information systems ~ Data mining

Keywords
Digital Government; Government 2.0; Social media; Visual analysis; Sentiment analysis

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1. INTRODUCTION
Governments around the world are increasingly adopting social media to reach out to and engage citizens. The concept of Government 2.0 refers to the adoption of Web 2.0 technologies by governments to socialize government services, processes and data [1]. Different from the classical content delivery introduced by Web 1.0, Web 2.0 offers natural mechanisms for interaction and participation. In particular, the use of Twitter by sectors of public administration has become a widely used mechanism to make announcements and assess public opinion. As government-citizen interactions become more participatory and multimedia-rich, there is a great opportunity for adopting advanced text mining and data visualization techniques to analyze this interaction and offer the findings as inputs to policy- and decision-making processes.

International organizations such as the United Nations Department of Economic and Social Affairs (UNDESA) and World Economic Forum (WEF) provide instruments that measure the advancement of countries around the world in utilizing digital technology for administrative and socio-economic development. Table 1 shows the 2016 rankings of five Latin American countries – Argentina, Chile, Colombia, Mexico and Uruguay according to UNDESA's e-Participation and e-Government Development indices [2] using relevant indicators of the WEF's Network Readiness Index [3]; the UNDESA instrument compares 193 countries while the WEF instrument compares 138 countries. The indices capture macro-level features that represent the advancement of digitization in a country, including government-citizen interactions supported by digital means. They provide a convenient context for measuring government-citizen interactions on social media platforms in such countries, for analyzing such interactions, and for integrating the findings into the countries' policy-making processes. With the exception of Brazil, the five selected countries occupy top positions in Latin America in the e-Participation index.

This paper proposes a methodology comprising a range of visualization techniques to analyze how governments use Twitter to carry out communication with citizens and how citizens respond. There is a wide range of visual analytics methods that can be used for this analysis [4]. The selected techniques include: 1) Event Drops to depict the level of activity over time, 2) Word Clouds to highlight the main topics discussed during a window of time, 3) Euler Diagrams to represent the volume of different types of resources shared by government and citizens, 4) Extended Hasse Diagrams to analyze varieties of government-citizen interactions,

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Table 1: Five country rankings based on the 2016 UNDESA and WEF Indices

Indices	Sub-indices	Provider	Countries				
			Argentina	Chile	Colombia	Mexico	Uruguay
E-Participation Index		UNDESA	60	32	27	14	39
E-Government Development Index		UNDESA	41	42	57	59	34
Individual Usage		WEF	53	52	71	84	44
	Use of Virtual Social Networks	WEF	53	37	89	91	64
Government Usage		WEF	111	39	31	52	27
	Importance of ICT's to government vision	WEF	137	68	46	71	59
Social Impacts		WEF	88	27	43	71	22
	E-Participation Index	WEF	54	7	11	45	3

5) Radar Charts to indicate types of emotions found in citizen responses, and 6) Annotated Line Charts to determine time series correlations resulting from different types of analyses.

It has been widely recognized in the literature that visual analytics can provide valuable inputs to decision-making in several domains such as financial monitoring [5], urban planning [6], customer retention [7], service coordination [8], crime analysis [9] and others. Visual analytics can also support policy processes in the areas of modeling [10], analysis [11], formulation [12], decision space navigation [13], etc. In particular, visual representations naturally reveal various patterns and trends resulting from the announcements made by governments through Twitter and other forms of social media and citizen reactions to such announcements. The practical implication of the proposed visualization techniques is providing deeper insights into data to aid decision support in digital government and public policy making in general.

The paper validates the application of the proposed techniques by examining government-citizen interactions on Twitter covering five government sectors, i.e. health, social development, education, work and environment in five selected countries in Latin America. This study explores activities that took place through the official Twitter accounts of the ministries responsible for the corresponding sectors in these countries. Given the time in which the research was conducted, the analysis used data published in the month of October 2017. The paper also outlines four application scenarios of the techniques: analyzing government social media communication strategies, assessing government-citizen interactions on social media, informing government decision-making based on such assessment, and supporting e-Participation benchmarking.

The paper is organized as follows. Section 2 reviews related work with particular focus on studies that examine government presence and the analysis of this presence on social media platforms, followed by research methodology in Section 3. Section 4 presents the six proposed visualization techniques and their applications to five government sectors in five Latin American countries, along with examples of specific insights gained from this type of analysis. The application of the proposed techniques also serves the purpose of validating them. Section 5 proposes four application scenarios of the proposed techniques, Section 6 discusses the findings and the final Section 7 concludes the paper.

2. RELATED WORK

Research and practice dedicated to digitization and transformation of public administration, government-citizen interactions, and the impact on public policy and development is generally taking place under the umbrella of digital government. Due to the ongoing changes in this domain, a useful concept is digital government evolution [14], which synthesizes the changes into four stages: digitization, transformation, engagement and contextualization. While the analysis of government-citizen interactions on social media is part of engagement, the insights gained could inform policy-making in health, social development, education, work, environment and other sectors as part of the contextualization stage, and directly contribute to sustainable development [15].

Concerning government-citizen interactions, a growing body of research literature examines government initiatives aimed at using social networking platforms such as Twitter or Facebook to engage citizens. For instance, a study of the Twitter use by municipalities to promote e-Participation in Saudi Arabia is reported in [16]. Similar but using an Irish city context, [17] examines e-Participation in municipalities based on an opinion-mining project.

A strategy for collecting data from government agencies' Twitter accounts and a webometric approach to identify e-Participation patterns are presented in [18]. A method to automatically "identify the public's stance against governmental decisions" is presented in [19]. Both papers also show how to automatically summarize citizen opinions and identify collective thinking patterns in e-Participation initiatives, by applying intelligent techniques based on contextualized search, opinion mining and argumentation.

The concept of passive crowdsourcing of e-Participation initiatives is discussed in [20]. The concept entails the search for content and the extraction of knowledge, ideas, and opinions expressed by citizens without any stimulation by government. A related framework that exploits multiple social media to carry out crowdsourcing in public sector initiatives is proposed in [21].

A methodology to systematically exploit social media content through the use of text analytics and opinion mining techniques is presented in [22][23]. The methodology can be used by government as part of policy-making processes. Another initiative focuses on exploring multiple social media for participative policy-making is outlined in [24]. Dedicated e-Participation platforms also include: bringing policy-makers and citizens closer through the WeGov toolkit [25], real-time analysis of e-Participation data [26], UbiPOL platform with policy-making workflow and business intelligence functionality [27], and social software infrastructure that integrates citizen-led and government-led deliberations [28].

The application of visual analytics to understand information embedded in open government data can be found in [29] while various applications of artificial intelligence and intelligent systems research in e-government and politics 2.0 are outlined in [30]. In

particular, social media analytics offers tools to collect, monitor, analyze, summarize and visualize social media data [31].

Finally, sentiment analysis can be used for different purposes, such as predicting social events, increasing citizen participation, and acknowledging citizens' political priorities. An analysis of blog posts of an e-Participation platform shows how sentiments can generate political participation and emotions increase participation [32]. The frequency of posts made by local governments through their Facebook accounts is combined with sentiment analysis to analyze success of government-citizen communication [33]. Another analysis determines if social events are reflected in the emotions detected in tweets and whether the detected sentiments can be used to predict certain events, such as riots or manifestations [34]. However, to the best of our knowledge, no studies exist so far that combine visual and sentiment analysis to examine government-citizen interaction on social media as done in this paper.

3. RESEARCH METHODOLOGY

This section describes the research methodology adopted in this paper. The research questions are put forward in Section 3.1, the data collected to address such questions is described in Section 3.2, and the analyses of this data is covered in Section 3.3.

3.1 Research questions

This study is driven by two main research questions. The first is: "How can visualization techniques assist in understanding government-citizen interactions on Twitter?" We refine this question to address issues such as: 1) the level of Twitter activity by governments in different countries and sectors, 2) topics that are addressed through such activities, 3) the resources shared through Twitter as part of such activities, 4) the intensity of citizen response to government activities, 5) the prevailing sentiment expressed by citizens in such responses, and 6) the combinations of such issues.

3.2 Data collection

To build the dataset for the analysis, we selected five Hispanic countries in Latin America: Argentina, Chile, Colombia, Mexico and Uruguay, based on the leading positions occupied by them in the region in the UNDESA's e-Participation Index [2]. We also selected five sectors: health, education, social development, work, and environment, and for each country and sector determined the official name and Twitter account of the responsible ministry or secretary. The results are included in Table 2.

The entire dataset consists of all tweets posted from the official accounts of the selected ministries or secretariats during the month of October 2017. The comments made by citizens in response to the tweets were also collected. The complete dataset comprised 7194 tweets from the ministries/secretariats and 5038 from citizens.

3.3 Data analysis

The dataset was analyzed and graphically represented using five visualization techniques: Event Drops, Word Clouds, Euler Diagrams, Extended Hasse Diagrams, and Radar Charts. These techniques are described as follows.

Event Drop is a graphical representation used to plot a measurable aspect of the analyzed data on a time series. The resulting visualizations are used to depict the level of activity of the government accounts over time. An example is shown in Figure 1.

Word Cloud is a graphical representation of the word frequency, an effective way to identify key topics in a passage or corpus of text. An example is shown in Figure 2.

Euler Diagram is a diagrammatic means to represent sets and their intersections, typically less complex than the equivalent Venn diagram since it represents non-empty intersections while the latter represents all possible logical relations between sets. They are used to represent different resource types (links, images and videos) shared by government accounts. An example is shown in Figure 3.

Extended Hasse Diagram is a modified form of Hasse diagrams that allows visualizing subset relations – the size of the nodes is proportional to the size of the sets. This technique is adopted to analyze the combinations of different types of citizen contributions (comments, retweets and favorites). An example is in Figure 4: Colored extended Hasse diagrams representing citizen response through comments, retweets and favorites …

Table 2: Ministry/Secretariat names (Spanish) and official Twitter accounts for each of the analyzed sectors.

Sectors	Countries				
	Argentina	Chile	Colombia	Mexico	Uruguay
Health	Ministerio de Salud	Ministerio de Salud	Ministerio de Salud y de la Protección Social	Secretaría de Salud	Ministerio de Salud Pública
	Msalnacion	Ministeriosalud	MinSaludCol	SSalud_mx	MSPUruguay
Social Development	Ministerio de Desarrollo Social	Ministerio de Desarrollo Social	Ministerio de Salud y de la Protección Social	Secretaría de Desarrollo Social	Ministerio de Desarrollo Social
	MDSNacion	dsocial_gob	MinSaludCol	SEDESOL_mx	Midesuy
Education	Ministerio de Educación	Ministerios de Educación	Ministerio de Educación Nacional	Secretaría de Educación Pública	Ministerio de Educación y Cultura
	EducacionAR	Mineduc	Mineducacion	SEP_mx	MEC_Uruguay
Work	Ministerio de Trabajo, Empleo y Seguridad Social	Ministerio de Trabajo y Previsión Social	Ministerio de Trabajo	Secretaría del Trabajo y Previsión Social	Ministerio de Trabajo y Seguridad Social
	Mintrabajo	MintrabChile	MintrabajoCol	STPS_mx	MTSSuy
Environment	Ministerio de Ambiente y Desarrollo Sustentable	Ministerio de Medio Ambiente	Ministerio de Ambiente y Desarrollo Sostenible	Secretaría de Medio Ambiente y Recursos Naturales	Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente
	Minisambiente	MMAChile	MinAmbienteCo	SEMARNAT_mx	Mvotma_Uruguay

Radar chart is a graphical method used to quantify several factors associated with an item or situation. This technique is particularly useful to show how different factors compare to each other in several situations. Radar charts are used in our analysis to quantify eight factors representing primary emotions on the examined data. Hence, they offer a visual approach to sentiment analysis. An example is shown in Figure 5.

Additional visualization techniques can be used to represent the results of combining different types of analysis. For instance, some techniques help determine if different types of activities are related to each other. As an illustration, we used annotated line charts to represent correlations between citizen responses and different types of resources such as links, images or videos shared by government. Text annotations are used to identify the salient topics when peaks of activity are observed. An example is shown in Figure 6.

4. VISUALIZATION TECHNIQUES

This section describes how the five adopted visualization techniques were applied to the five sectors in five countries in Latin America, illustrates how they could be combined to carry out more complex analysis, and shares the insights. The section is structured into parts: activity analysis (Section 4.1), identification of salient topics (Section 4.2), analysis of resource sharing (Section 4.3), analysis of citizen interactions (Section 4.4), sentiment analysis (Section 4.5) and combined analysis (Section 4.6).

4.1 Activity analysis

A simple approach to analyzing government presence on social media is quantifying activity levels on Twitter and other channels. The visualization of the activity levels of a government institution in a given country offers insights into whether deviations from normal activity levels occur at certain times. Combining context and activity analysis helps bring out the relevant factors that resulted in higher levels of activity which, in turn, helps identify particular events of special interest to government and the society.

Figure 1 offers a graphical representation of the activity levels on Twitter of each of the five sectors in the countries analyzed in the month of October 2017. In addition to assessing the total number of posts per institution, this analysis helps identify salient events that occurred in these countries in particular days in October 2017. The peak activity levels are observed for the Ministries of Health, Social Development, and Education and Culture of Uruguay. The examination of the tweets posted by these ministries identifies two major events that could have been the sources of such peaks, namely the "World Health Organization Global Conference on Non-Communicable Diseases", which took place in Montevideo during 18-20 October, and the "Second Meeting of the Regional Conference on Social Development in Latin America and the Caribbean", which was held in Montevideo during 25-27 October.

Other events that occurred during October 2017 could be also identified. For instance, the Mexico's Secretariat of Environment and Natural Resources announced in early October 2017 its intent to sign the "Revillagigedo National Park Decree" through which the government commits to the conservation of the Revillagigedo Archipelago. It is also interesting to investigate the high levels of activity registered by the Colombian Ministry of Health and Social Protection during 23-27 October. The examination of the tweets posted by the Ministry reveals announcements on various topics, but most of them focused on preventing mosquitoes-transmitted illness, using the *#ContraLosMosquitos* (against the mosquitoes) hashtag. An activity peak is also registered by the Chilean Ministry of Education during "Professor Day", which is celebrated on 16 October, and by the Argentinean Ministry of Education during a nation-wide evaluation of prospective teachers on 31 October.

In addition to event drop diagrams for each sector, Figure 1 also depicts the visualization of the total activity levels of each country after adding all sector-specific activities. The order from the most to the least active country, considering the number of posts published is: Colombia (2244), Chile (1729), Mexico (1721), Uruguay (1250) and Argentina (406). Additional visualizations are at http://ir.cs.uns.edu.ar/publications/ downloadextra/84.pdf.

4.2 Identification of salient topics

Word clouds are graphical representations that allow visualizing the frequency/relevance of a group of words to summarize a text or a text corpus. The more frequently a word is mentioned in the text (or text corpus), the larger it appears in the word cloud; the colors are used for design purposes only. Word clouds are an effective way to highlight the most salient topics in a given context and are a useful tool to sift through a large number of tweets.

Figure 2 depicts the word clouds associated with the tweets posted by the Social Development Ministries/Secretariats of Mexico, Chile, Uruguay and Argentina; Colombia does not have a dedicated to Ministry of Social Development. The analysis of these word clouds makes it possible to identify the main topics addressed by the social development sector of these countries during October 2017. In particular, one of the most common terms used by the Secretariat of Social Development of Mexico was *Sismo* (earthquake), reflecting the occurrence of earthquakes that hit Mexico in September 2017. The term *Chiapas* is also prominent given the major damage to infrastructure produced by the earthquake in the Chiapas state and the actions taken by the Secretariat after the event. The hashtag *#FuerzaMéxico* (strength to Mexico) was also frequently used in this context. Different from Mexico, the Social Development Ministry of Chile did not focus on specific topics during the analyzed period. Its announcements include mentions to the Chilean Minister of Social Development (*Marcos Barraza*) and to the process known as *"Proceso Constituyente Indígena"*, which aims at enabling indigenous and tribal communities to participate in decision-making processes that affect their lives. In Uruguay, the announcements made by the Social Development Ministry put particular emphasis on the words *mujeres* (women) and *jóvenes* (young people). Similarly, the Argentinean Social Development Ministry also made references to *jóvenes* but also includes topics such as *programas* (programs), *actividades* (activities) and *talleres* (workshops). It also refers to the hashtag #ElEstadoEnTuBarrio (the state in your neighborhood), which is a program that facilitates access to services and benefits for citizens in their neighborhoods.

This type of analysis enables identification of major events that affect a particular sector of a country during a specific period. It should be noticed that while certain terms are commonly used at all times, others are distinctive of a given event, as in the analyzed example associated with the 2017 Mexico earthquake.

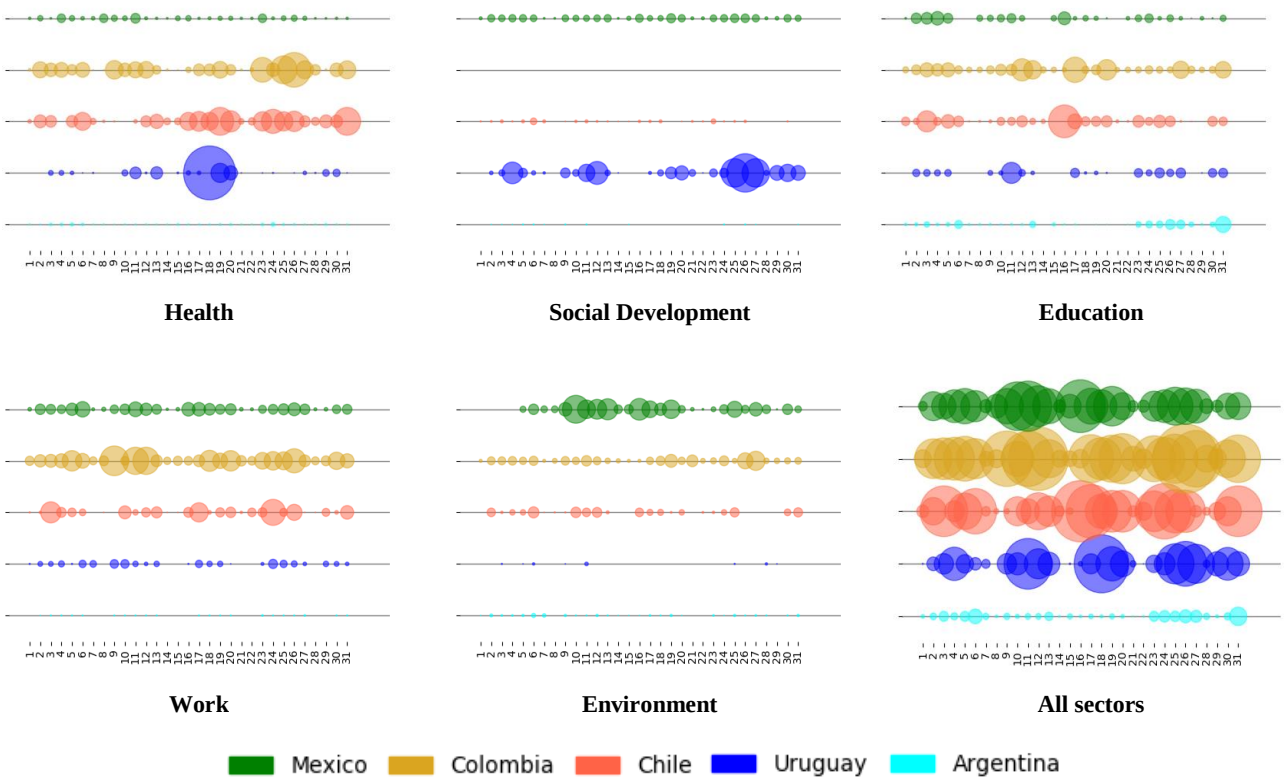


Figure 1: Event drop diagrams depicting activity levels of each sector and all sectors combined.

Figure 2: Word clouds highlighting the main topics addressed by the Social Development Ministries/Secretariats.

4.3 Analysis of resource sharing

Government can communicate with citizens by sharing different types of resources, such as links, images and videos. The analysis of the volume of resources of different types shared by government in different sectors reveals preferred approaches to making announcements and engaging citizens. In our analysis, we adopted a graphical representation based on the colored Euler diagrams, where color intensity represents occurrence degree – the higher the intensity, the more times the resource type occurs.

In Figure 3 (a), the colored Euler diagrams help recognize the most common resource sharing strategies adopted by the education sector of the five countries during October 2017. For instance, Mexico posted 119 tweets containing links, three with images, and two with videos. It also posted 51 tweets containing both links and images. Interestingly, Mexico shares mostly links while Colombia shares mostly images. More generally, Figure 3 (b) visualizes the number of resources of each type shared by each sector across the five countries. From this analysis, the work and health sectors share most resources, with images being the most common resource type.

4.4 Analysis of citizen interactions

Measuring the number of comments posted by citizens in reply to government posts quantifies the degree of citizen participation. In addition, other forms of citizen responses, such as marking a tweet as favorite or retweeting it, can also be measured and analyzed.

We adopted colored extended Hasse diagrams to examine different forms of responses. At the bottom of the diagram, we depict the total number of interactions. One level up specifies the numbers of interactions of specific types, i.e. comments, retweets and favorites. One level up represents possible combinations of different types of responses and their occurrences. Finally, the top level of the diagrams specifies the number of simultaneous occurrences of comments, retweets and favorites. Different colors identify

different types of interactions, with circles scaled up to represent numbers of interactions. For clarity, the sizes of circles are not coordinated across countries. Figure 4(a) presents a visualization of the number of comments, favorites, and retweets posted by citizens in response to announcements made by the Secretaries/Ministries of Work in each of the analyzed countries. In general, the number of comments is smaller than the number of retweets or favorites. In most cases, the tweets marked as favorites are also retweeted. It is worth mentioning that in this sector, Colombia has the highest level of participation, while Argentina has the lowest. A comparison between activity levels for the work sector in Figure 1 and the degree of citizen response in Figure 4(a) indicates that the countries with the highest activity levels (Colombia, Mexico and Chile) are also the ones with the highest levels of citizen interaction.

More generally, Figure 4(b) presents the total number of comments, favorites and retweets posted by citizens in response to the tweets made by the five ministers/secretaries in each of the five countries.

The analysis established a correspondence between government activity levels on Twitter and the degree of citizen response. In addition, the countries with the highest UNDESA e-Participation index (Table 1) are also the ones that report the highest levels of activity on Twitter during the analyzed period. However, this correspondence is not exact. For instance, Colombia which ranks 27th in the e-Participation index reports a higher activity level than Mexico, which ranks 14th. A similar comparison could be made with the WEF index which puts Colombia as the first among the five analyzed countries. Further analysis is needed to determine if the tendencies shown here can be generalized for longer periods.

(a) … by Ministries/Secretariats of Education in each country.

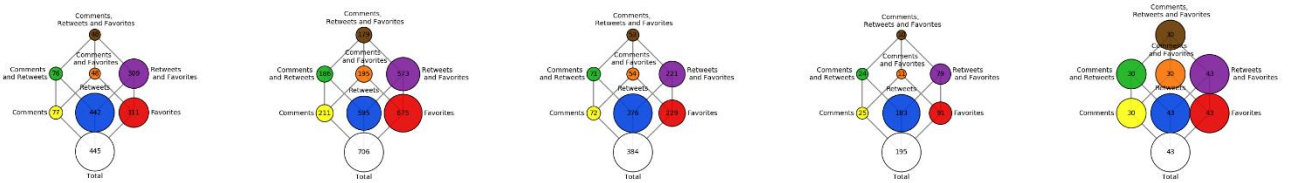
Mexico **Colombia** **Chile** **Uruguay** **Argentina**

(b) … by each sector across the five countries.

Health **Social Development** **Education** **Work** **Environment**

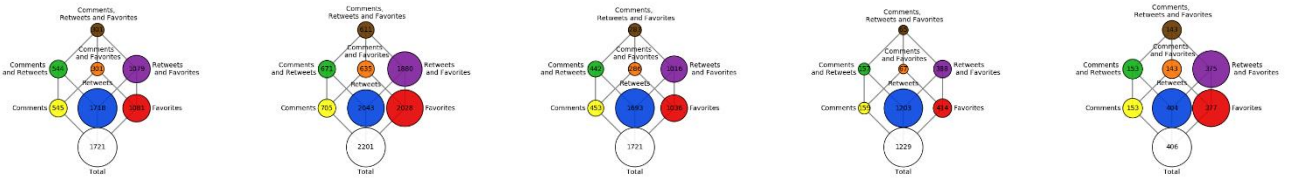
Figure 3: Colored Euler diagrams showing number of links, images and videos shared…

(a) … to tweets by Ministries/Secretariats of Work in each country.



Mexico **Colombia** **Chile** **Uruguay** **Argentina**

(b) … to tweets by all Ministries/Secretariats in each country.



Mexico **Colombia** **Chile** **Uruguay** **Argentina**

Figure 4: Colored extended Hasse diagrams representing citizen response through comments, retweets and favorites …

4.5 Sentiment analysis

Sentiment analysis was carried out on citizen comments based on the Plutchik wheel of emotions [35]. According to Plutchik's theory, there are eight primary emotions: joy, trust, fear, surprise, sadness, disgust, anger and anticipation. A simple technique to carry out sentiment analysis on a text corpus is to rely on a lexicon that captures word-emotion associations and to count the number of occurrences in the corpus associated with each emotion. This technique allows estimating which are the prevailing emotions in the analyzed text corpus. Our analysis was carried out using the Spanish version of the NRC Affect Intensity Lexicon [36]. For illustration, Table 3 contains examples of the Spanish words associated with eight primary emotions with English translations.

This analysis was applied to assess the general mood of the citizens of a country in response to the tweets made by particular government ministries/secretaries. After applying this technique to the comments posted by citizens, we generated graphical representations to visualize the prevailing emotions found in the analyzed comments. Figure 5 presents the resulting graphical representations for the health sector. This analysis makes it possible to recognize that trust is the most common emotion for the tweets originating in the health sector, while in some countries such as Argentina or Uruguay fear is almost as common as trust.

Table 3: Spanish words associated with eight primary emotions and their translations to English [36].

Joy	felicidad	happiness	genial	great
	feliz	happy	maravilloso	wonderful
Trust	lealtad	loyalty	ayudar	help
	responsable	responsible	agradable	nice
Fear	asustado	scared	peligroso	dangerous
	cobardía	cowardly	terror	terror
Surprise	asombro	astonishment	incidente	incident
	impredecible	unpredictable	sorprendente	surprising
Sadness	condolencia	condolences	dolor	pain
	depresión	depression	duelo	mourning
Disgust	deshonestidad	dishonesty	suciedad	dirt
	corrupción	corruption	aberración	aberration
Anger	enfado	anger	queja	complaint
	molesto	annoyance	crimen	crime
Anticipation	intento	attempt	ansia	craving
	conjetura	guess	anhelo	longing

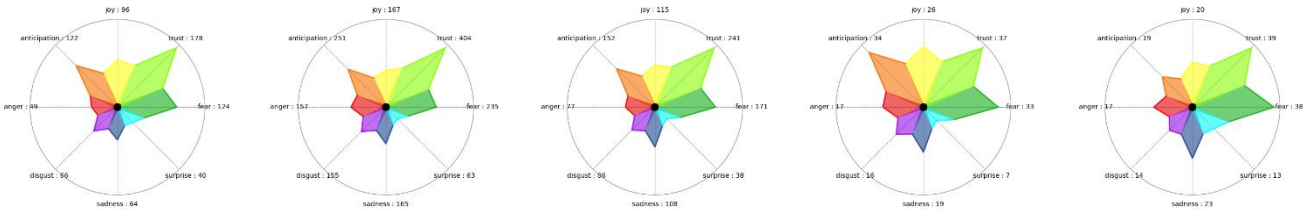


Figure 5: Radial charts showing emotions in citizen responses to the posts made by the Health Ministries/Secretariats in the five analyzed countries.

4.6 Combined analysis

To illustrate how different types of analyses can be combined, we examine possible correlations between the numbers of images, videos, links and tweets posted by the Argentinian Ministries and the level of citizen response using comments, retweets and favorites. The time series correlation across a one-month period for the Argentinean Ministry of Health shown in Figure 6 indicates that images, links and tweets generate a higher level of response from citizens than videos. Text annotations make it possible to determine the salient topics when peaks of activity are observed.

The bar charts in Figure 7 show the correlated values computed between the four types of official activity, i.e. links, videos, images and tweets posted, and the three types of citizen responses, i.e. comments, retweets and favorites, for five public sectors in Argentina. For the health sector, there are high correlations between citizen response and all types of official activity, except video sharing. Other sectors have strong positive correlations between citizen responses and all types of official activity including video sharing. The same analysis conducted for all countries can be found at http://ir.cs.uns.edu. ar/publications/downloadextra/84.pdf. In general, strong positive correlations exist between official activity and citizen responses for all countries and sectors. However, a few exceptions with no apparent correlation can be also identified. Other forms of combined analysis could include sentiment analysis to identify correlations between types of emotions such as trust or fear in responses to particular policy announcements or could focus on detecting the topics that generated the most polarized reactions from citizens, e.g. the responses reflecting joy or anger.

5. APPLICATION SCENARIOS

The visualization techniques proposed and validated in this paper could support policy-makers and government officials in assessing and enhancing government communication strategies. This is just one scenario for the application of the proposed techniques.

The aim of this section is to elaborate on this and other application scenarios, namely: 1) analyzing social media communication strategies of government organizations; 2) benchmarking social media strategies between government organizations; 3) targeting social media communication strategies to specific groups; 4) diagnosing the results of international e-Participation rankings; and 5) piloting public policy initiatives with active monitoring of citizen reactions and sentiments. We argue below that the first four scenarios were validated through the examples presented in this paper. For the fifth scenario, we outline an approach and plan the development a detailed framework as part of our future work.

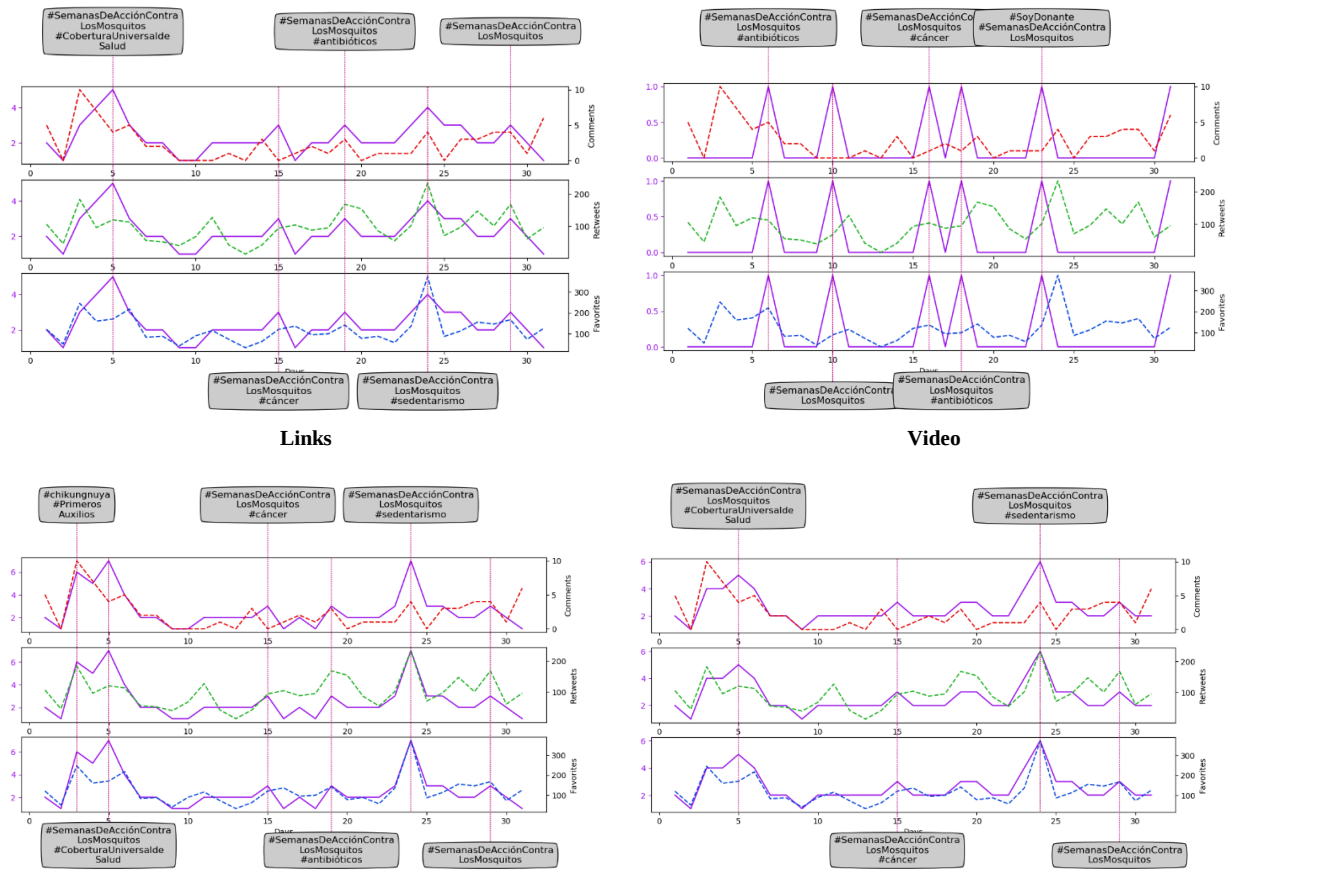


Figure 6: Annotated line charts showing correlations between links, video, images and tweets posted by the Argentinean Ministry of Health and citizen comments, retweets and favorites.

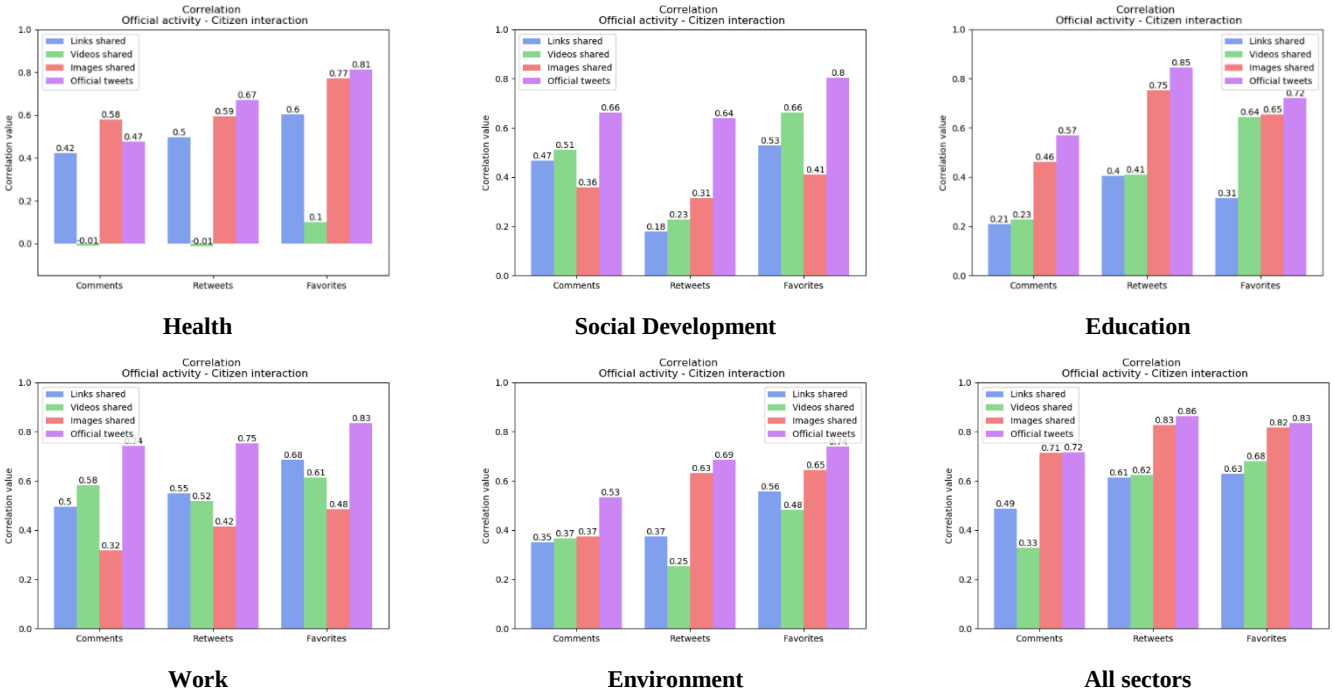


Figure 7: Bar charts showing correlations between links, videos, images and tweets posted by the five Argentinean ministries and comments, retweets and favorites expressed by citizens.

Scenario 1 – Analyzing social media communication strategies of a government organization: The Event Drops diagrams in Figure 1 enable assessing the Twitter use by government organizations. For example, Uruguay and Chile seem not to use Twitter during weekends. The Word Cloud technique helps clearly highlight the key issues communicated and how they relate to the events that affect the society. As shown in Figure 2, while in Mexico most tweets refer to the earthquake and in Uruguay to major events, in Chile, they mostly refer to the Minister himself.

Scenario 2 – Benchmarking social media strategies of a government organization compared with other organizations: The Event Drops, Euler, Extended Hasse and Bar Charts diagrams can be used for benchmarking social media communication strategies of a government organization. This can involve peer benchmarking to compare similar organizations, or aspirational benchmarking to compare the organization with leading organizations in social media use. For instance, the diagrams in Figure 1 identify the Colombian Ministry of Work as the most active Twitter user and a potential aspirational benchmarking for Argentinean institutions. The Bar Chart diagrams in Figure 7 could be also used to assess citizen reactions to government posts as a way to benchmark communication strategies of peer organizations.

Scenario 3 – Targeting social media communication strategies of a government organization on specific groups: The Colored Euler diagrams could help analyze the type of resources shared in tweets, in order to assess if proper means were used to reach the targeted audience. For example, if the target audience are vulnerable groups with low levels of literacy, they could be targeted through images and videos. Videos would be only advisable if the targeted audience has access to broadband Internet, otherwise links are preferred. In addition, Bar Charts that show correlations between the types of resources shared and citizen reactions to them can also help analyze how the targeted audience reacts to communicated messages.

Scenario 4 – Diagnosing the results of international e-Participation rankings: The Event Drops, Colored Euler and Colored Extended Hasse diagrams can help understand the results of e-Participation rankings and assist governments in finding areas for improvement in their communication strategies. For instance, they can help compare the use of Twitter in various countries, as in Figure 3. At the international level, Figure 1 confronts the UNDESA's e-Participation Index, since during the assessed period and for the government sectors analyzed, while Mexico is ranked first by the index, Colombia is more active on Twitter.

Scenario 5 – Piloting public policy initiatives with active monitoring of citizen reactions/sentiments: Radial charts that display emotions enable analyzing how citizens react to policy initiatives. For instance, governments or parliaments can measure citizen reactions to draft bills of law or to policy drafts by using sentiment analysis through Radial Charts, or by measuring citizen interests through Extended Hasse diagrams and incorporating the findings in the law-making or policy-making processes.

6. CONCLUSIONS

This paper examined government-citizen interactions on Twitter using several visualization techniques. The aim was to propose a methodology for this type of analysis and to illustrate it by examining government activity and citizen response on Twitter in five Latin American countries during one month. We conclude that the proposed techniques based on visual and sentiment analysis offer a valuable approach to analyzing government presence and citizen participation on social media.

The proposed methodology is part of the last stage of a process that collects information from Twitter, processes this information and finally presents the findings in a user-friendly way to facilitate understanding and interpretation. The information processing stage should include the cleansing of the collected data to detect trolling, spamming, and gathering additional information to help understand the context of the values shown, including the percentage of users and interactions presented on the visualizations in relation to the entire population. Without this stage, the visualization can lead to under-estimation or over-estimation of the displayed values, and the consequent misinterpretation of the results.

The proposed techniques exemplify approaches to graphically representing the analyzed data. As the study was applied over a limited period of time and on a small set of countries, a broader investigation is needed to validate the usability of the approach. Also, the described techniques are a small subset of a range of methods that could be used to analyze government-citizen interactions. More complex analysis could be carried out by integrating these and other techniques. For instance, a combination of techniques could visualize salient topics and prevailing emotions across a time series or help identify announcements that generate the most controversy among citizens.

More limitations of the study are: as the methodology was applied to Twitter only, an extension to other social media channels is needed; there is also a need to further explore combined approaches such as those in Section 4.6 to apply statistical functions and to triangulate results produced by various forms of visualizations; and further research is needed to apply the proposed methodology for benchmarking communication strategies between countries with different languages and ways of expressing emotions.

In the future, we plan to explore other visualization techniques, explore various forms of combined analysis, support piloting policy initiatives by monitoring citizen reactions, and extend the coverage to longer periods. We also plan to improve the lexicon used for sentiment analysis by adaptation to specific study domains. Finally, the presented methodology can be applied to other social media platforms like Facebook or Instagram, considering their own mechanisms of interaction between users and available retrieval methods provided by their Application Programming Interfaces.

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