# CivisAnalysis: Interactive Visualization for Exploring Roll Call Data and Representatives' Voting Behaviour

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Fig. 1. CivisAnalysis's Overview module, showing the political spectrum of parties as a flow along 24 years and six legislatures. Parties are colored according to the *Ideology Color Palette*. The 49th legislature—the first elected by direct vote after the military regime—is still marked by the polarization of left-wing and right-wing parties. The polarization weakens along the legislatures due to the need of establishing a coalition government.

***Abstract*—We present CivisAnalysis, a web-based system for the visualization of roll calls of Brazil's Chamber of Deputies that can give citizens a unique view of the country's political history. Covering roll calls of six legislatures as well as six presidential elections, CivisAnalysis combines roll call visualization techniques with techniques for the visualization of temporal data. In this work, we provide a visualization of roll call results as a n-dimensional space, coupling votes with the spectrum of deputies and the votes of a set of deputies with the spectrum of roll calls. We also provide a long-term political timeline integrated with election data (election results and political alliances). Our tool supports textual and visual filtering and includes auxiliary visualizations that provide an overview of the political scenario regarding deputies, parties, coalitions and their behavior along time. We also report a remote user study conducted to evaluate CivisAnalysis.**

***Keywords*-Political data visualization; roll calls visualization; political spectrum.**

## I. Introduction

Active and informed citizens are essential for a healthy democracy, but being informed about public affairs has become a challenging task due to the immense size of modern representative democracies. In representative democracies, the most important tool of citizenry is the vote, which is how citizens can provide feedback that may improve the democratic system. To be able to vote effectively, a citizen needs consistent political information, especially regarding the actions of elected representatives. Political data about representatives

can be found in every part of their public lives: speeches, interviews, meetings, etc. However, their votes in congress are especially important as they have a direct impact on society. How representatives behave in roll calls is thus an invaluable source of data that can be used to keep citizens informed.

During roll calls, each representative explicitly chooses an option regarding a matter that is being decided ("Yes", "No" or "Abstention"). Beyond this individual choice, each option in a roll call can reveal the behavior of groups in congress and in society at large. Each representative vote is directly associated to an electoral district and a party; indirectly, it is associated to personal characteristics such as religion, gender, wealth, etc. This makes roll call votes a reliable data set for understanding representatives' policies in several aspects.

This work focuses on roll calls that have taken place in the Brazilian Chamber of Deputies, the lower house. The Chamber is formed by 513 deputies elected by proportional representation in electoral districts to serve four-year terms. Brazil has 27 electoral districts, each with a minimum of 8 and a maximum of 70 seats; the exact number being proportional to the each district's population. Proportional representation and flexible electoral alliance laws make it possible for Brazil's multi-party system to have a large number of parties. The last legislature (2011-2014), with 21 parties, voted in 352 roll calls (a total of 114,994 votes). This large number of votes makes it impractical for common citizens to track their representatives' voting records.

Open-data government initiatives gave access to different political data sets, allowing for the easier dissemination of information. On the other hand, the huge volume of unorganized and highly biased information spread across the Internet may cause a negative impact on the assimilation of information due to the effect commonly known as information overload. It is therefore challenging to retrieve cohesive information from the political big data and communicate it to the common citizen.

The inspection of a single roll call without assistance of a tool is feasible, but usually one may also need/want to obtain information concerning larger periods of time—e.g., retrieving votes of different sets of deputies (e.g., parties, alliances and districts) linked to sets of roll calls (possibly about a specific subject) within a specific time interval. An exploration tool to quickly test hypotheses is therefore necessary to be able to draw conclusions about larger and/or different political contexts.

Using the open data from the Chamber, we developed CivisAnalysis, a visualization tool aimed at making it easier and quicker to discover and understand congressional voting patterns. This tool integrates state-of-the-art and new visualization techniques for roll calls analysis, using a data set that covers voting records of six legislatures (24 years)—comprising 914 motions voted through 2,458 roll calls (853,952 votes)—as well as the information of six presidential elections, including election results and alliances made for the elections. By providing several exploration features, the tool allows for the discovery of the voting pattern of any arbitrary number of roll calls in the deputies data set as well as the voting pattern of any arbitrary number of deputies in the roll calls data sets, along different time frames across legislatures.

This work's main contributions are:

1) a visualization of the outcome of roll calls as an n-dimensional space, linking the votes of a set of roll calls with the political spectrum of deputies and—vice versa—the votes of a set of deputies to the roll calls political spectrum;
2) the integration of long-term political and electoral data (result and alliances) in the roll call analysis.

In the next section, we present background and related work. Then, we present our tool, which is called CivisAnalysis, describing its several features based on how it can be used to fulfill different queries that typical users might want to pose. We also report the results of its use by people with different levels of expertise. Finally, from a user's viewpoint, we discuss the importance of such data for the analysis of the Chamber, and, from a computational viewpoint, we comment on the improvements we foresee as future work.

## II. Background and Related Work

### A. Alliances and Legislatures in Brazil

In Brazil, every four years a general election is held: the Presidency of the Republic, all 513 Chamber of Deputies seats and two-thirds of the 81 Federal Senate seats are contested, along with governorships and state legislatures in all 27 States. Executives are elected by simple majority; Representatives are elected by open-list proportional representation (parties choose the candidates, voters choose the party and preferred candidate), seats being allocated through a variant of the d'Hondt method [1]. Electoral alliances are counted as a single party, the votes being distributed inside the alliances to the leading candidates without considering the parties. As such, electoral alliances do not respect citizens' preferences of vote regarding parties.

In Brazil, post-election alliances (coalitions) are formed in order to create a multi-party, pro-government majority as well as the opposition group. The ideological spectrum of parties in the Brazilian legislature term is partially reduced to a government-opposition dimension. Studies on Brazilian legislatures and coalitions cite the important role of presidential elections and electoral alliances on the patterns of legislative behavior [2][3][4]. As such, having electoral alliances and coalitions as parameters for the visualization may be an important part of the process of analyzing the data extracted from the behavior of representatives during roll calls.

### B. Roll Call Analysis

Today, most theories of campaigns, legislatures and elections are based, explicitly or implicitly, on the spatial model of politics. Studies aim at positioning each political player at its ideal point on a spectrum [5]. This produces techniques with results that can be interpreted both in probabilistic and in geometric terms. Researchers estimate congressional spaces from transcripts of hearings, bill co-sponsorships, public opinion surveys, committees seats, campaign contributions and roll call

votes [6][7]. Roll calls are commonly used in spatial models because of their nature of reliably expressing the policy of each representative. The Spatial Theory of Voting put into practice with roll call analysis was concisely highlighted by Clinton [8]: "In short, roll call analysis makes conjectures about legislative behavior amenable to quantitative analysis, helping make the study of legislative politics an empirically grounded, cumulative body of scientific knowledge."

The Poole and Rosenthal algorithms [9], known as the NOMINATE family, are widely used in roll call analysis and compare favorably to more modern algorithms [10]. In contrast to the complexity of previous methods, fast and less accurate techniques are used, such as Principal Component Analysis (PCA). PCA or Karhunen-Loeve transformation [11] reduce the number of dimensions while retaining the variance of the data. These dimension reduction techniques try not to crush different points together, but remove correlations. The remaining subset of dimensions are a compact summary of the variation in the original data. Despite the relative inaccuracy of PCA to find ideal points on the roll call space, the voting patterns formed are quite similar to those obtained with more complex methods [12].

### C. Visualization of Political Data

Political spectrum visualizations are widely used to represent different political positions in one or more geometric axes that represent independent political dimensions. Systems based on such visualizations try to provide ways of solving the problem of how to describe the political variation in a given space. Early systems were usually built around questionnaires and regression analysis and are often considered highly biased because constant adaptation was needed to represent different political contexts [13]. A popular political spectrum on the Internet, created using questionnaires, is Political Compass [14], which provides spectra of different countries and specific elections.

In order to reduce bias, modern systems tend to use only quantitative information about representatives, especially from recorded votes. In this case, the political spectrum is built based on the results from roll call analysis techniques. Spatial models created by roll call analysis techniques are traditionally represented as scatterplots, where representatives are displayed as points whose positions represent their values associated to the variable axes. As such, the closer points are, the more their corresponding representatives' policies agree. To help identify representatives, a table can be used. Nowadays, it is possible to apply interactive techniques over the spectrum to identify neighbor points and calculate distances between representatives.

Connect 2 Congress (C2C) [15] creates a two-dimensional political spectrum (through NOMINATE scores and Leaders-Followers) of the U.S. Congress for arbitrary time frames within two years (2007-2008). Representatives can be filtered and highlighted (by name, state, party, religion and gender). The time frame can be dynamically modified, resulting in an animation where representatives are continuously repositioned according to their behavior. C2C does not have inter-legislature analysis as it comprises only two years. Social Action [16] takes an alternative approach to spectrum visualization, representing the correlation of votes between U.S. senators as a force-directed graph. Social Action also lets users interactively apply filters and statistical tools to uncover patterns of voting groups at single points in time.

As for the Brazilian Congress, Marino [17] and Basometro [18] create a two-dimensional spectrum and adjust the scales along a diagonal axis according to government coalition and opposition in a way similar to Rosenthal's NOMINATE analysis of France legislatures (anti/pro-regime axis) [19]. Marino's work is based on a year by year animation of PCA analysis. Basometro, from the Estadão newspaper, uses two criteria of "government support" and implements deputy tracking on a growing window animation, similar to C2C.

To address the temporal variation of political positions in a single visualization, some techniques provide a long-term overview using political timelines, which are compact visualizations of political trajectories of individuals or parties over time. Friggeri and Fleury's visualization [20] shows the paths of U.S. senators through agreement groups for eight Congresses using a custom clustering algorithm applied to roll call data. The webcomic Xkcd [21] presented a large poster where DW-NOMINATE scores were used to create a political timeline of the U.S. Congress since 1788. Xkcd's visualization also shows annotations of historical events, presidents, control of the chamber, new and leaving members, and noteworthy members represented apart from their party. Moody *et al.* [22] represented the U.S. Senate's political polarization using a dynamic coalition network. In each period, there are two "party loyalist" node-cluster positions, anchored on the y-axis proportional to a modularity score, representing the polarization. Other nodes, usually individuals, are based on the balance of their votes relative to these anchors. Despite being informative, these political timeline techniques are not interactive, not permitting a detailed inspection of the associated roll calls.

## III. CivisAnalysis

We developed CivisAnalysis to help citizens explore the data from the Brazilian Chamber of Deputies's open web services (www.camara.gov.br).

The design of CivisAnalysis was driven by questions made by common citizens about politics, which can be interpreted as citizen tasks (CT) supported by our tool. They comprise analysis of roll calls, analysis of voting patterns of deputies and parties and complex questions about legislative behavior along time, as follows:

1) What were the roll call's results? a) How did the deputies vote? b) How did the parties vote? c) How did the districts vote? d) Was there a dispute between government and opposition? 2) Which deputies voted alike? 3) Which parties voted alike? 4) Which deputy is politically divergent from his or her party? 5) How can we identify roll calls with similar disputes? 6) In which roll calls a party's members did not vote alike? 7) Which parties make up electoral alliances? And

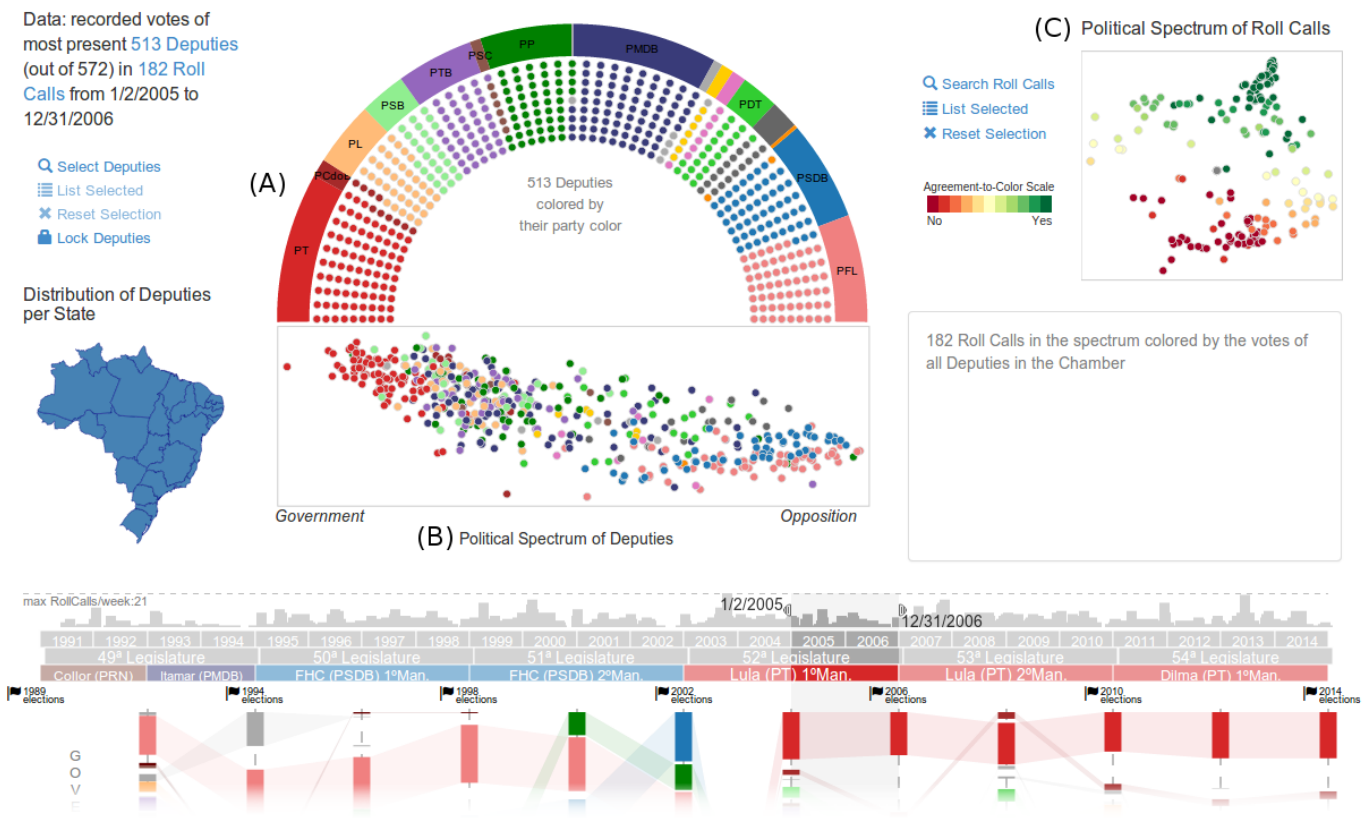



Fig. 2. CivisAnalysis's Inspection module, depicting the Brazilian Chamber of Deputies in 2005-2006 (selected in the timeline of legislatures at the bottom). (A) shows the distribution of deputies per party, sorted by deputy positions in (B), which depicts the political spectrum of deputies. On the right, (C) shows the political spectrum of roll calls. At the bottom, part of the Overview module with the timeline.

coalition governments? 8) How did parties and deputies behave across different legislatures? a) Is their behavior aligned to ideology? b) Or is it aligned to government coalitions?

In the next sections we describe our tool using these citizen tasks as arguments in the discussion of each visualization component.

### A. Overview

The first screen users access in CivisAnalysis is the *Overview Module* (Fig. 1), which presents them with an overview of 24 years of the Brazilian Chamber of Deputies's history, displaying in chronological order presidents, legislatures, general elections and the placements of parties in the spectrum. To obtain details on roll calls and deputies, users can select a period of time. When a period is selected, the *Inspection Module* is opened.

The *Inspection Module* has multiple views of the roll call data set. In the *Chamber infographic* (Fig. 2.A), users can inspect the deputies sorted by parties. Deputies can be analyzed individually in the *Spectrum of Deputies* (Fig. 2.B). The *Spectrum of Roll Calls* shows how roll calls relate to one another (Fig. 2.C). To represent the geographic properties of the data set, we display electoral districts on a map, with users being able to click on a district to select it. Since roll calls, deputies, parties and districts are strongly bonded, the *Inspection Module* extensively uses techniques of coordinated views. User actions in one view are thus reflected in all the others.

CivisAnalysis is an open source project (hosted at https://github.com/fgborja/CivisAnalysis) implemented as a web application capable of running on any modern browser. All roll call analysis techniques and spectrum creation, search and filtering functions run on client-side — the web server is free from CPU/memory intensive processes. The roll calls are loaded on demand using XMLHttpRequest. Inspection of all legislatures requires the client's browser to load the entire data set (currently around 40MB). CivisAnalysis is scalable, not demanding powerful web servers or too much bandwidth.

### B. Political Spectrum

The spectrum is relative to a period in time, its start and end dates provided by users as parameters. Given a time period, we find $N$ roll calls voted by $M$ deputies and build the political spectra of both deputies and roll calls, which are shown separately in space but logically linked for interaction, as we will discuss later in this section.

For both deputies and roll calls the spectrum is created using the same algorithm, PCA by Singular Value Decomposition (SVD) [23]. Despite political scientists' preference for NOMINATE analysis, PCA analysis has advantages: it

is fast, it allows for real-time computation on the client-side and it shows patterns [12] similar to the ones identified by NOMINATE.

*Deputy Set:* Elected deputies that are called for positions in the Executive or that run for municipal elections are not part of the legislature for the entirety of its term. As such, the number of deputies participating in roll calls that took place during the selected periods is larger than the expected 513 seats of the Chamber of Deputies. To approximate the best representation of the Brazilian Chamber of Deputies during the period we select only the 513 Deputies who were most present in the roll calls. This way, negligent deputies will be excluded, resulting in a slightly different number of seats than the elected by parties and states.

*Recorded Votes Matrix:* The second step to compute the political spectrum is to build a matrix of recorded votes. Consider the matrix ***A*** *(M x N)*, with *M = 513* deputies and *N* roll calls and where each cell ***X(m,n)*** represents the vote of the *mth* Deputy in the *nth* roll call. The value of each vote is defined as: 1 for *Yes*, -1 for *No*. In case of missing data, vote abstention or obstruction, the cell's value is set to 0.

*Computing the Spectrum:* We apply the SVD algorithm on the recorded votes matrix ***A***, obtaining the following matrices:

$$\underbrace{A}_{513\times N} = \underbrace{U}_{513\times 513} \times \underbrace{\Sigma}_{513\times N} \times \underbrace{V^T}_{N\times N} \quad (1)$$

The two-dimensional *Spectrum of Deputies (513 x 2)* is calculated by multiplying the two largest singular values found in $\Sigma$ by the left-singular vectors of ***U***.

The two-dimensional *Spectrum of Roll Calls (N x 2)* is calculated by multiplying the two largest singular values found in $\Sigma$ by the right-singular vectors of ***V***.

### C. Overview Module

Following the approach of *overview first, and details on demand* [24], the application starts with the summary of party positions on the spectrum along time, with presidents, legislatures and general elections of the last 24 years of the Brazilian Chamber of Deputies being displayed chronologically. The goal is to give users an overview of how parties behaved in the Chamber. It aims at a quantitative reasoning of *CT* 8a and *CT* 8b.

To obtain specific details about a period, users can select arbitrary time frames on the timeline by clicking on specific presets (e.g., years or legislatures) or by using the brushing tool. Fig. 2 shows the selection of the period from January of 2005 to December of 2006.

*Party Timeline:* The Party Timeline displays the political spectrum of parties as rectangular elements anchored on the y-axis for each two-year period. The party's position in the spectrum is related to the average of the position of the party's deputies in the spectrum. The height of the party in the flow is relative to the number of deputies of the party in each period. Since many parties have close roll call policies, the elements can be cluttered on the y-axis. To prevent cluttering, we included a simple *Unclutter* function, where parties' sizes and political distances can be perceived without any obstruction. This function sorts the parties according to their spectrum positions. The height of the elements and the distances between them are calculated according to the percentage of pixels users want to use to represent the political distance between parties or parties' size. The application provides a configuration settings menu to allow users to change this percentage or display the parties' original positions in the spectrum. Fig. 1 shows the result of the use of the *Unclutter* function, with parties' size filling 45% of the y-axis.

### D. Inspection Module

The *Inspection Module* consists of different views of the roll call data set for a selected time period. The views display important variables that should be considered in the roll call analysis: parties, deputies, roll calls (votes) and electoral districts. These variables relate to one another: a party is represented by a set of deputies; a district is represented by a set of deputies; a deputy has a set of roll call votes; a roll call has a set of deputy votes.

To reveal these relations, the views are coordinated in order to express subsets of the data as demanded by users. User actions in one view affect all the other views. For example, selecting a single roll call results in highlighting the data of this roll call in all the other views: deputies will have their colors changed to represent their vote in the roll call based on a *Vote-to-Color* map; parties and districts will have their color changed to represent the votes made by their respective set of deputies using an *Agreement-to-Color* scale.

*Agreement-to-Color Scale:* This is a function that maps the vote agreement scale [(100% "Yes" votes) to (100% "No" votes)] to a color scale [green to red]. For example, a roll call with only "No" votes will be colored red; a roll call with 70% "Yes" votes and 30% "No" votes will be light green—the roll call had a moderate agreement favorable to "Yes."

*Vote-To-Color Map:* This is a function that maps a single vote ["Yes," "No," "Obstruction," "Abstention," Chamber President, absence] to a color [green, red, blue, purple, yellow, gray].

*Chamber Infographic:* To represent the role of parties and deputies in roll calls *CT* 1a and *CT* 1b, the Chamber Infographic displays the deputies and parties sorted by their position in the political spectrum. The parties are sorted according to the average position of their deputies in the spectrum of deputies. We adopted the semi-circle design because it is a common representation of assemblies, chambers or legislative houses. A half-donut chart is aligned with the chamber to represent the proportion of parties. Users can select party and deputy elements by clicking; hovering over them displays more information. Fig. 2 depicts a selection of all the parties, while Fig. 3 shows how divergent deputies can be identified using the Chamber Infographic, thus providing support for *CT* 4. If users select one or more roll calls (Fig. 4 and Fig. 5) in the roll calls spectrum, the color of the parties is changed to reflect how their deputies voted using the Agreement-to-Color scale.

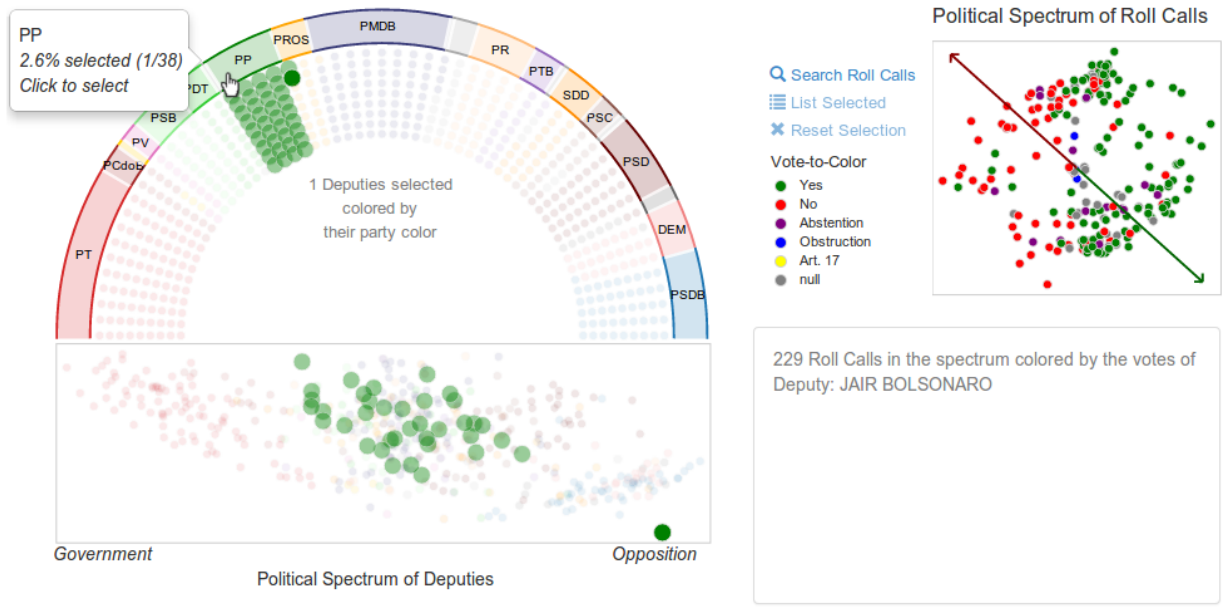



Fig. 3. The cursor is hovering over the Progressive Party (PP), which has only one selected deputy, shown as the non-transparent circle: Jair Bolsonaro is an electoral success with radical political views. We can observe, in the Spectrum of Deputies, his distance from his party and his polarized position. The Spectrum of Roll Calls represents the votes of the selected deputy using the Vote-to-Color map. Jair Bolsonaro's positive and negative variance ("Yes"/"No" votes) is represented as a vector in the roll calls spectrum.

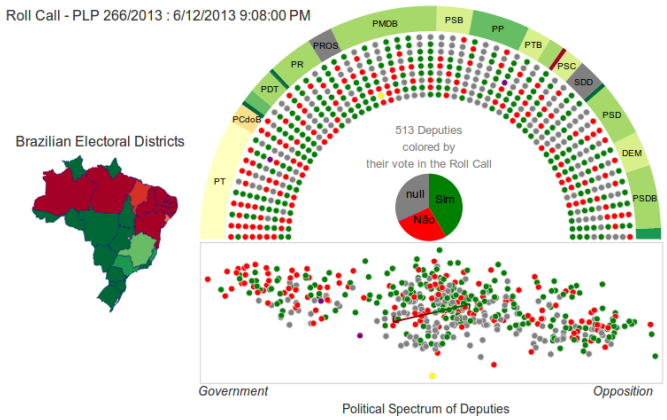



Fig. 4. Selection of roll call PLP 288/2013, which comprised amendments to the Participation of States Fund law. The selection links the roll call votes to deputies, parties and districts. Deputies are colored using the Vote-to-Color map; parties and districts with the Agreement-to-Color scale. The central pie chart shows the proportion of votes. We can see the disagreement of parties that resulted of a dispute between northern and southern districts.

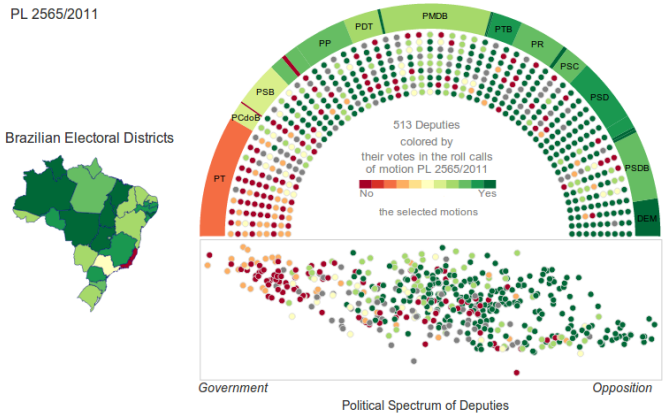



Fig. 5. The proposed bill PL 2565/2011 aimed at an equal distribution of oil royalties to all the states and the use of these royalties for education only. The visualization depicts the votes of this bill's three roll calls. Reddish elements gave more "No" votes. We can notice at a glance that the dispute was between districts that are oil producers (in red), those that are not, and the government party (PT).

*Spectrum of Deputies:* To analyze each deputy individually, the Spectrum of Deputies is presented as a scatterplot. Each Deputy is represented as a circle positioned according to PCA. The closer deputies are, the more similar their votes, helping support *CT* 2. Users can select deputies by clicking or brushing and can get more information by hovering over them with the cursor. By default, deputies are drawn in their respective party's color. When a single roll call is selected, deputies colors change—according to the Vote-to-Color map (Fig. 4)—to represent their vote in the roll call. If a set of roll calls is selected, deputies colors change—according to the Agreement-to-Color scale (Fig. 5)—to reflect their votes in the roll calls. For example, if a deputy voted "Yes" in 30% of the roll calls and "No" in 70%, he or she will be colored in light red since his/her votes in the selected roll calls are moderately favorable to "No".

To reinforce the idea of coupling between the roll calls and deputies' spectra, arrows representing the vectors of positive and negative ("Yes"/"No" votes) variance are shown in the Spectrum of Roll Calls (see Fig. 3).

*Spectrum of Roll Calls.:* To let users directly inspect roll calls and make it easier for them to find similar roll calls, we designed the Spectrum of Roll Calls as a scatterplot where each roll call is represented as a circle. Users can select roll calls by clicking or brushing and can hover over them with the cursor to display the amendments summary. The spectrum axes represent the same components as the Spectrum of Deputies, so the distribution of roll calls is closely related to the distribution of deputies in their spectrum. The close distance between roll calls expresses their voting similarity, which is adequate for *CT* 5.

To increase the representativity of the spectrum, roll calls circles are colored using the Agreement-to-Color scale. Roll calls in dark red are those that received only "No" votes, while those in dark green got only "Yes" votes. In the transition from red to green, it is possible to identify where impasses occurred: they are colored with a neutral color (light yellow). By default, roll call colors represent the votes of all the deputies of the Chamber (see Fig. 2), although users can select a subset. For example, by selecting one of the parties, the roll call colors will change to show only the votes of its members (see Fig. 6), thereby making explicit which roll calls the party's deputies had agreed or disagreed (*CT* 6). The same logic applies when selecting districts or any arbitrary set of deputies.

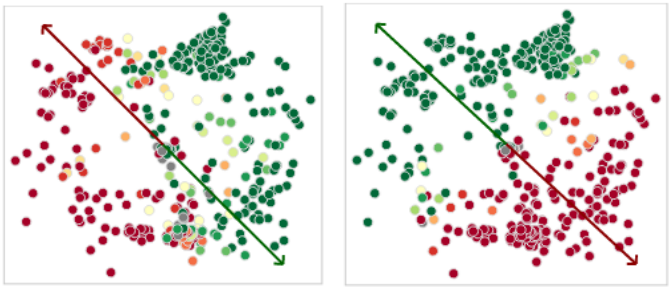
*Visual Filters:* CivisAnalysis provides interactive filtering, letting users create selections and compare them using the coordinated views. Parties, states, deputies and roll calls can be selected by left-clicking: this operation will select only the corresponding elements (i.e., left-click on a state element select all deputies from that state) and deselect others. The left-click can be combined with the *Ctrl* key to add elements or with the *Shift* key to exclude elements from the current selection. Each filtering operation modifies the views on-the-fly: for example, selecting states and parties causes only votes in which related deputies participated to be displayed on the spectrum of roll calls.

*Textual Filters:* Deputies and roll calls can be searched for and filtered using textual keywords. Deputies are indexed by name, party and state. Roll calls are indexed by the identifier, the motion summary and tags that are provided by the Brazilian Chamber of Deputies. Roll calls texts are in Brazilian Portuguese.

*Parties Color Palette:* Party colors are fully customizable. When first loaded, CivisAnalysis displays the overview using the *Diff Major Parties* palette, which is an arbitrary selection of colors that makes the main parties visually distinguishable from each other (Fig. 2). The other option is the *Ideology Color Palette*, which categorizes the parties in left-wing, center and right-wing parties, as shown in Fig. 1, to assist users reasoning in *CT* 8a and *CT* 8b.

## IV. Evaluation and Discussion

CivisAnalysis was informally evaluated by different people throughout its development. The current version underwent a remote user study addressing specific aspects. In this section we briefly describe this evaluation and discuss the results.



(a) Selection of PSDB (b) Selection of PT

Fig. 6. Antagonist voting patterns formed in the Spectrum of Roll Calls after selection of opposition and government parties. The yellowish circles are roll calls where members of the same party disagree.

### A. Remote User Study

The study was focused on a population of users that were potentially interested in analyzing the data from the Brazilian Chamber of Deputies. We aimed at evaluating the intuitiveness of our design choices with respect to both visualization and interactive features. We set up a questionnaire and sent the survey to professors and researchers of different areas, students and designers via mailing lists. No introduction or tutorial about CivisAnalysis was given prior to the study. In the short period of five days we received 15 complete responses.

Most of our 15 subjects are male (80%, 12 out of 15). They are in average 33 years old, with their ages ranging from 21 to 49. Among participants, 5 are professionals (4 are software engineers and 1 is a designer), 5 are computer science (CS) graduate students and 5 are professors (4 CS and 1 human sciences professor). We asked how often they read news about politics and obtained the following profile: 5 (33.3%) read daily; 4 (26.7 %) read 3 to 4 times a week; 2 (13.3%) read 1 to 2 times a week, and 4 (26.7%) rarely read this type of news. As to whether they had ever seen visualizations of political data, 50 % of our subjects reported that they had seen them before, mostly infographics about the 2014 elections.

Our questionnaire was designed to measure the understanding of the visualization components through eight questions with a five-point Likert scale of agreement (1 meaning strongly disagree to 5, strongly agree): (1) understanding the parties' flow, i.e., their positions in a government-opposition spectrum along time; (2) understanding configuration controls of the parties' flow; (3) understanding how to select time intervals in the timeline; (4) understanding the political spectrum of deputies; (5) understanding the political spectrum of roll calls; (6) assessing the ease of selecting deputies; (7) assessing the ease of selecting roll calls; and (8) assessing the filtering and selection controls.

In general, we had a positive feedback on both *Overview* and *Inspection* modules. The main roll call analysis functions were performed and understood by users. Tasks *CT* 1 to *CT* 4 could be easily executed in the *Inspection Module*; *CT* 7 and *CT* 8, in the *Overview Module*. As for *CT* 5 and *CT* 6, users found difficulties, with their main doubt being about the roll

call spectrum calculation. As expected, the main complaints were the lack of information about the techniques and the lack of a glossary (about legislative procedures) and online help.

### B. Results

The *Party Timeline*, in the *Overview Module*, was the best understood component: 60% marked "Strongly agree" and 40% marked "Agree", with a total of 100% of agreement.

Regarding the interactive timeline controls, the level of understanding was also high both for the configuration controls (80% of agreement) and the selection of time intervals (93.3% agreement). One user reported difficulties to select or follow small parties because they have a small height in the visualization due to their small number of deputies. Party spectrum positions after application of the *Unclutter* function was preferred over their original, but there were concerns because these positions can change according to the function's parameters.

As for the *Inspection Module*, the political spectrum of deputies was well understood by the subjects (80% of agreement) and they also found it easy to select deputies (86.7% of agreement). Although less understood, the political spectrum of roll calls got 73.3% of agreement in understandability. They also considered it easy to select roll calls (86.7% of agreement). However, interactive selection tools in the Chamber of Deputies representation, the map and both scatterplots, as well as the text-based search, were not very well understood: 66.7% of users found them understandable, while 20% were undecided and 13.3% did not understand them.

Five out of 15 subjects found it difficult to understand the political spectrum of roll calls, especially how the two spectra relate to one another. Most users reported that they missed legends, hints and clear explanations about some of the components in the visualizations.

One of our subjects said that CivisAnalysis is "an application with a huge potential of going viral on social media networks." Our preliminary evaluation suggests that CivisAnalysis covers common information-seeking citizen tasks.

## V. Final comments

Civis Analysis offers a unique view of the Brazilian Chamber of Deputies's political history. The overview provided by the *Party Timeline* motivates exploration of specific time frames. The *Inspection Module*, with its coordinated views and several selection and filtering features, allows users to investigate both group and individual behaviors. One can explore and compare voting patterns of different legislatures, observe party behavior over time, investigate party or electoral district patterns, relate the pre- and post-election alliances with government and opposition, coalitions, etc.

Features could be added to our application to allow for a deeper investigation: the tracking of individual behavioral over time, an overview of parties and deputies for more than one legislature, a navigation over tabular data, etc. Advanced tools to emphasize information in the roll calls spectrum could be added as well: advanced infographics for a selected roll call, finding and relating (historically) roll calls of the same legislative motion (e.g., amendments to a bill), and an improved search and analysis of roll calls by subject. We also plan to implement other dimensionality reduction techniques to compare with SVD.

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## References

[1] V. d'Hondt, "La représentation proportionnelle des partis par un électeur," *Ghent.(1882). Systdme pratique et raisonng de repre'-sentation proportionnelle. Brussels: Muquardt*, 1878.

[2] C. J. Zucco, "Ideology or what? legislative behavior in multiparty presidential settings," *The Journal of Politics*, vol. 71, pp. 1076–1092, 7 2009.

[3] S. Krause and R. Schmitt, *Partidos e coligações eleitorais no Brasil*. Unesp, 2005.

[4] S. Morgenstern, *Patterns of legislative politics: Roll-call voting in Latin America and the United States*. Cambridge University Press, 2004.

[5] J. M. Enelow and M. J. Hinich, *The spatial theory of voting: An introduction*. CUP Archive, 1984.

[6] D. R. Fisher, P. Leifeld, and Y. Iwaki, "Mapping the ideological networks of american climate politics," *Climatic change*, vol. 116, no. 3-4, pp. 523–545, 2013.

[7] S. W. Desposato, "Parties for rent? ambition, ideology, and party switching in brazil's chamber of deputies," *American Journal of Political Science*, vol. 50, no. 1, pp. 62–80, 2006.

[8] J. Clinton, S. Jackman, and D. Rivers, "The statistical analysis of roll call data," *American Political Science Review*, vol. 98, no. 02, pp. 355–370, 2004.

[9] K. T. Poole and H. Rosenthal, "A spatial model for legislative roll call analysis," *American Journal of Political Science*, pp. 357–384, 1985.

[10] R. Carroll, J. B. Lewis, J. Lo, K. T. Poole, and H. Rosenthal, "Comparing nominate and ideal: Points of difference and monte carlo tests," *Legislative Studies Quarterly*, vol. 34, no. 4, pp. 555–591, 2009.

[11] R. Dony, "Karhunen-loeve transform," *The transform and data compression handbook*, 2001.

[12] A. Jakulin and W. Buntine, "Analyzing the us senate in 2003: Similarities, networks, clusters and blocs," 2004.

[13] J. Lester, "The evolution of the political compass (and why libertarianism is not right-wing)," *Journal of Social and Evolutionary Systems*, vol. 17, no. 3, pp. 231–241, 1994.

[14] P. Compass, "Political compass," 2013. [Online]. Available: http://www.politicalcompass.org/

[15] P. Kinnaird, M. Romero, and G. Abowd, "Connect 2 congress: visual analytics for civic oversight," in *CHI'10 Extended Abstracts on Human Factors in Computing Systems*. ACM, 2010, pp. 2853–2862.

[16] A. Perer and B. Shneiderman, "Integrating statistics and visualization for exploratory power," 2009.

[17] R. Marino, "A valsa dos partidos, de collor a dilma," 2014. [Online]. Available: http://www.todasasconfiguracoes.com/2014/04/24/a-valsa-dos-partidos/

[18] E. de So Paulo, "Basmetro," 2013. [Online]. Available: http://estadaodados.com/basometro/

[19] H. Rosenthal and E. Voeten, "Analyzing roll calls with perfect spatial voting: France 1946–1958," *American Journal of Political Science*, vol. 48, no. 3, pp. 620–632, 2004.

[20] A. Friggeri and E. Fleury, "Agreement Groups in the United States Senate," in *IOGDC - International Open Government Data Conference*, 2012. [Online]. Available: http://hal.inria.fr/hal-00705682

[21] R. Munroe, "A history of the united states congress, partisan and ideological makeup," http://xkcd.com/1127/large/, accessed: 2015-03-31.

[22] J. Moody and P. J. Mucha, "Portrait of political party polarization," *Network Science*, vol. 1, no. 01, pp. 119–121, 2013.

[23] G. H. Golub and C. Reinsch, "Singular value decomposition and least squares solutions," *Numerische Mathematik*, vol. 14, no. 5, pp. 403–420, 1970.

[24] B. Shneiderman, "The eyes have it: a task by data type taxonomy for information visualizations," in *Visual Languages, 1996. Proceedings., IEEE Symposium on*, Sep 1996, pp. 336–343.