Trend Analysis of Regime Change and Social Unrest with Laplace Test Statistic

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Outline

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Problem

- Regime Change and Social Unrest.
  Why is Important to Understand and Predict?
- Polity Data.
- Collaborative Data Sharing and Analysis Platform.

We Propose

- Collaborative Decision-assist System.
- Web-based Platform.
- Algorithm for Trend analysis of regime change and social unrest.

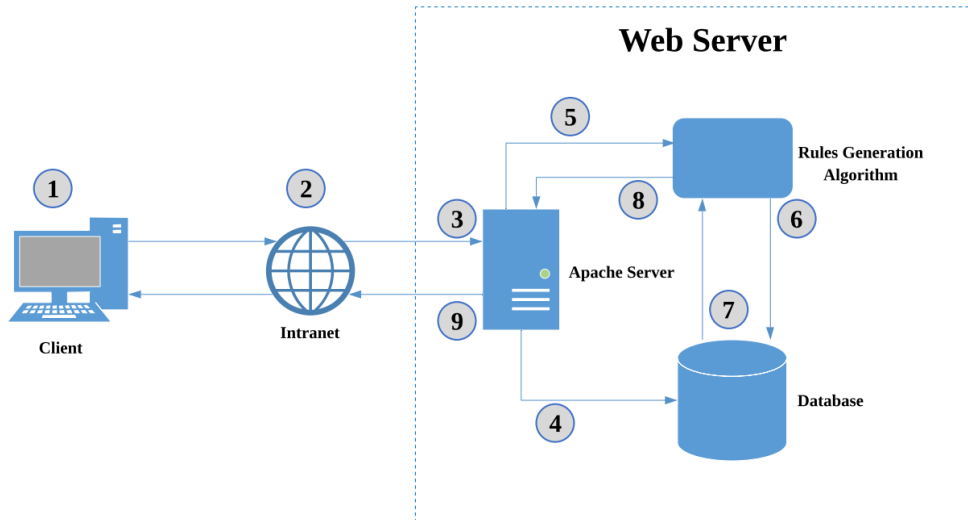# Previous Effort: Decision Assist Rule Extraction Process
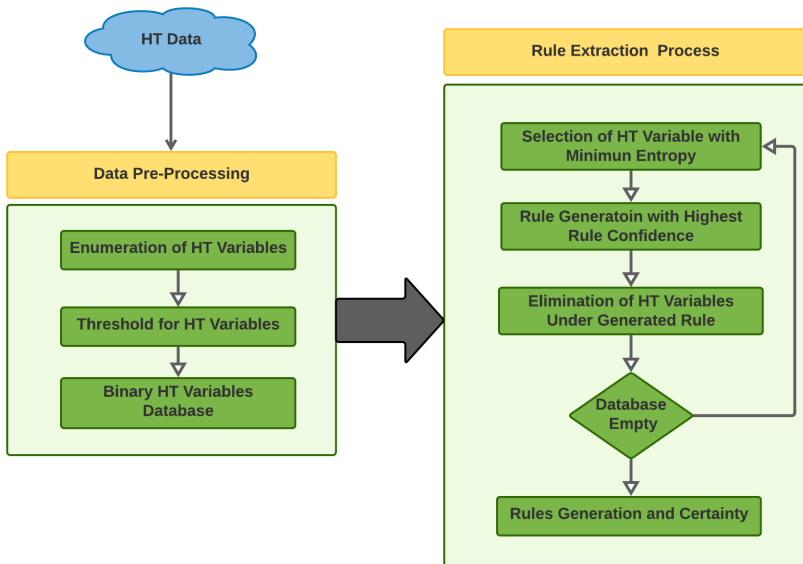
C. Díaz-Cáez and C. Kim, "A web-based data analysis platform for collaborative decision assistance," in 23rd International Conference of Artificial Intelligence, 2021.

Outline

Illustration - Web-based Platform Environment

Webpage/Interface Design and Development

Outline

Data Analysis Platform

Web-based Trend Analysis

- Web-based collaborative platforms facilitate cooperative interactions globally, enhancing collaboration in various sectors.

- Crucial for resource consolidation and identifying common data patterns, these platforms foster a shared understanding and support the development of tailored systems.

- Utilizes the Laplace test statistic in trend analysis to differentiate between constant and escalating event rates, crucial for real-time threat prediction.

Laplace Statiscit

- Adjusts probability estimates to avoid zero probabilities, enhancing model robustness in fields like natural language processing and machine learning.

- Ensures non-zero probabilities for all events, improving models by accommodating unseen or infrequent events.

- Quantifies smoothness in time series for trend analysis, revealing significant shifts or trends for data-driven decision-making.

Trend Analysis with Laplace Statistic

Statistical Trend Insights

- he Laplace statistic assesses event distributions, assuming events are uniformly spread over an observation period. It uses the Probability Density Function (PDF) to calculate the mean value, which helps in identifying significant trends and frequencies of precursor events.

Mathematical Formulations

$$f(x) = \frac{1}{T-0}, \quad 0 \leq x \leq T \quad (1)$$

Probability Density Function with n events uniformly distributed over $[0, T]$

$$\mu = \int_0^T x * f(x)\, dx = \frac{T}{2} \quad (2)$$

(μ) or expectation $\mathbb{E}(X)$ for the aforementioned PDF

$$s = \frac{1}{T} \int_0^T x^2\, dx - \left[\frac{T}{2}\right]^2 = \frac{T^2}{12} \quad (3)$$

Variance $\mathbb{V}(X)$ or s with the definition of $\mathbb{V}(X) = \mathbb{E}(X^2) - [\mathbb{E}(X)]^2$

$$\sum_{i=1}^n t_i = n * \mu = \frac{nT}{2} \quad (4)$$

Sum is approximately equal to n times the mean of PDF

$$\sum_{i=1}^n t_i - \frac{nT}{2} \approx 0. \quad (5)$$

If we subtract the mean occurace time $nT/2$ from the sum of occurrances times $\sum_{i=1}^n t_i$, the resulting difference would be zero

Trend Analysis with Laplace Statistic - Cont. 1

Laplace Test Statistic

• Dividing the difference by the standard deviation of occurrence times transforms it into a standard normal distribution, such as

$$\frac{\sum_{i=1}^{n} t_i - \frac{nT}{2}}{\sqrt{\frac{nT^2}{12}}} = \frac{\sum_{i=1}^{n} \left(t_i - \frac{T}{2}\right)}{T\sqrt{\frac{n}{12}}} \approx N(0,1). \tag{6}$$

• Equation 6 represents the Laplace test statistic, with various versions; our work uses a specific variation, expressed below.

$$U_L = \frac{\frac{1}{n}\sum_{i=0}^{n}\left(t_i - \frac{T}{2}\right)}{T\sqrt{\frac{1}{12n}}} = \frac{\mu - \frac{T}{2}}{T\sqrt{\frac{1}{12n}}}. \tag{7}$$

• Equation (7) helps identify event patterns but has limitations with small samples, making trend detection challenging due to gradual changes in U_L.

Trend Analysis with Laplace Statistic - Cont. 2

Coding for Laplace Statistic

Algorithm 1: Real-time Laplace statistic calculation

Input: A series of timed events $Time$
Output: Prints the calculated statistics for each event

1 Initialize $tempsum$ to 0
2 **for** *each event i in Time* **do**
3   Add the event's time to $tempsum$
4   Calculate the cumulative sum and average time up to this event
5   Calculate the Laplace statistic $L[i]$ for this event
6   **if** *this is not the first event* **then**
7   Calculate the standard deviation $s[i]$ of the time up to this event
8   **if** *standard deviation is not zero* **then**
9   Adjust the Laplace statistic $La[i]$ to account for the standard deviation
10   **end**
11   **end**
12   Print the statistics for this event
13 **end**

Adjusted Lapalce Statistic

To address the aforementioned limitations, an adjusted Laplace test statistic, U_{AL}, is proposed to approximate a standard Gaussian distribution, calculated as $U_{AL} = \frac{U_L \cdot \mu}{s}$, where μ is the mean and s is the standard deviation. Both U_L and U_{AL} are equally reliable for trend analysis, sharing the same critical threshold based on the z-value, regardless of sample size.

Outline

Validation

Polity IV Data Set

www.systemicpeace.org/inscrdata.html

	A	B	C	D	E	F	G	H	I	J	
1	year	fragment	democ	autoc	polity	durable	xrreg	xrcomp	xropen	xconst	
2	1999	nan	8	1	7	0	3	3	4	7	
3	2000	0	9	0	9	0	3	3	4	7	
4	1930	nan	0	5	-5	0	1	nan	nan	1	
5	1946	nan	0	9	-9	0	2	1	4	1	
6	1994	nan	nan	nan	nan	0	nan	nan	nan	nan	
7	1995	nan	3	2	1	0	2	2	4	3	
8	2005	0	1	4	-3	0	2	1	4	3	
9	1930	nan	nan	nan	nan	0	nan	nan	nan	nan	
10	1931	nan	7	3	4	0	3	3	4	7	
11	1944	nan	10	0	10	0	3	3	4	7	
12	1987	nan	0	3	-3	0	1	nan	nan	3	
13	1990	nan	6	1	5	0	2	2	4	6	
14	2006	0	0	3	-3	0	1	nan	nan	3	
15	2007	0	0	4	-4	0	1	nan	nan	2	
16	2014	0	3	1	2	0	2	nan	nan	4	
17	1814	nan	1	5	-4	0	3	1	2	3	
18	1830	nan	3	4	-1	0	3	1	2	5	
19	1848	nan	6	0	6	0	3	3	4	5	
20	1851	nan	nan	nan	nan	0	nan	nan	nan	nan	
21	1852	nan	0	8	-8	0	2	1	4	1	
22	1869	nan	2	5	-3	0	2	1	4	5	

| Polity IV: Regime Authority Characteristics and Transitions Datasets			
User's Manual PDF	Polity IV Annual Time-Series, 1800-2017	Polity IV Project, Political Regime Characteristics and Transitions, 1800-2017, annual, cross-national, time-series and polity-case formats coding democratic and autocratic "patterns of authority" and regime changes in all independent countries with total population greater than 500,000 in 2017 (167 countries in 2017) (SPSS and Excel data; PDF codebook). Click here for the list of changes made during the year 2017 annual data update (SPSS and Excel file; PDF codebook).	SPSS Series
	Polity IVd Polity-Case Format, 1800-2017		SPSS Case
Codebook PDF	Coups d'Etat, 1946-2017	Center for Systemic Peace, Coups d'Etat, 1946-2017, event list includes successful, attempted, plotted, and alleged coup events reported in Keesings Record of World Events (Keesings Online) and other sources; successful coups are cross-referenced to the Polity IV data series to distinguish "adverse regime changes" from "autocratic coups"; also listed in the codebook are cases of leadership change that are not considered coups (e.g., assassinations, ouster by foreign forces, victory by rebel forces, forced resignation) (Excel coup list and Excel time-series; PDF codebook).	Excel Coups List

POLITY IV. Regime authority characteristics and transitions datasets (2017) Open-Free source:
http://www.systemicpeace.org/inscrdata.html

Validation

Laplace statistic results for Bahrain

Laplace Statistic for Ccode 692 Bahrain
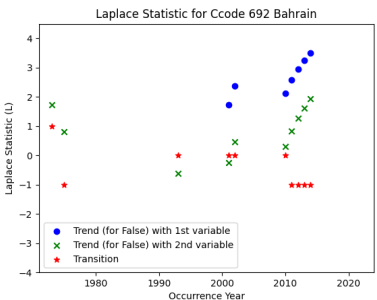
Laplace Statistic					
1st Variable	UL1	2nd Variable	UL2	Transition Year	Transition
0	0	0	0	1973	1
2001	1.73	1973	1.73	1975	-1
2002	2.37	1975	0.82	1993	0
2010	2.11	1993	-0.62	2001	0
2011	2.58	2001	-0.24	2002	0
2012	2.94	2002	0.46	2010	0
2013	3.24	2010	0.3	2011	-1
2014	3.49	2011	0.82	2012	-1
		2012	1.25	2013	-1
		2013	1.62	2014	-1
		2014	1.93		

Validation

Laplace statistic results for Venezuela

Laplace Statistic for Ccode 101 Venezuela
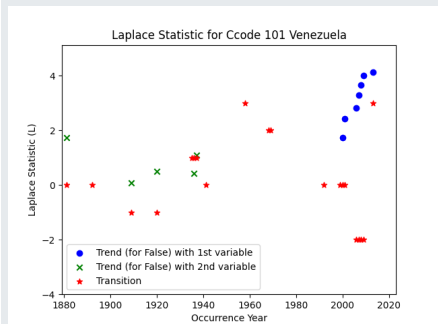
Laplace Statistic					
1st Variable	UL1	2nd Variable	UL2	Transition Year	Transition
0	0	0	0	1881	0
2000	1.73	1881	1.73	1892	0
2001	2.43	1909	0.08	1909	-1
2006	2.82	1920	0.5	1920	-1
2007	3.27	1936	0.43	1935	1
2008	3.65	1937	1.1	1936	1
2009	3.99			1937	1
2013	4.12			1941	0
				1958	3
				1968	2
				1969	2
				1992	0
				1999	0
				2000	0
				2001	0
				2006	-2
				2007	-2
				2008	-2
				2009	-2
				2013	3

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Illustration - Web-based Platform Environment

1 C. Ansell and A. Gash, "Collaborative governance in theory and practice," Journal of public administration research and theory, vol. 18, no. 4, pp. 543–571, 2008.

2 C. Díaz-Cáez and C. Kim, "A web-based data analysis platform for collaborative decision assistance," in 23rd International Conference of Artificial Intelligence, 2021.

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4 Y. Luo, T. Bergander, and A. B. Hamza, "Software reliability growth modelling using a weighted laplace test statistic," in 31st Annual international Computer Software and Applications Conference (COMPSAC 2007), vol. 2. IEEE, 2007, pp. 305–312.

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7 C. Kim, "Identification of symptom parameters for failure anticipation by timed-event trend analysis [power distribution systems]," IEEE power engineering review, vol. 20, no. 9, pp. 48–49, 2000.

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9 M. G. Marshall, "Polity IV: Regime authority characteristics and transitions datasets," Statistical database. Vienna: Center for Systemic Peace. Available at: www.systemicpeace.org/inscrdata.html (accessed July 3, 2017). Development and poverty in SSA, vol. 105, 2017.

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