ThermalPlot: Visualizing Multi-Attribute Time-Series Data Using a Thermal Metaphor

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https://thinkh.github.io/paper-2015-thermalplot/#publication

ThermalPlot Technique

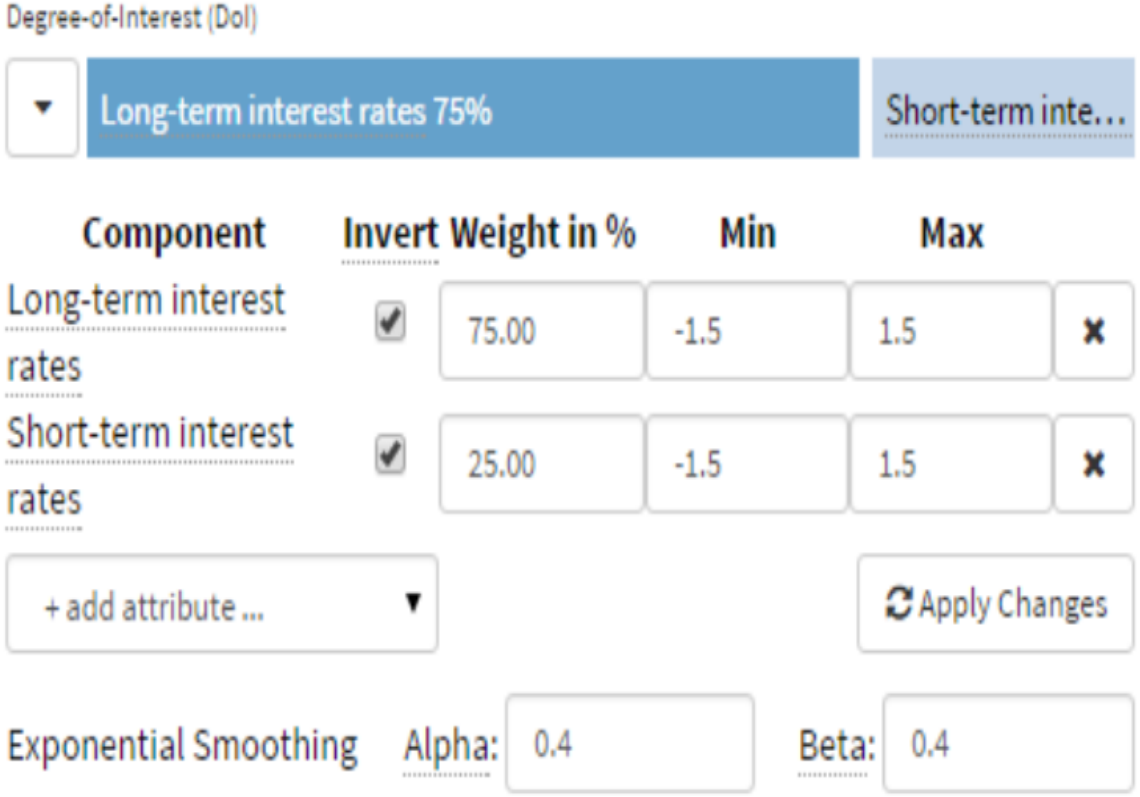
- Multi-attribute time-series data
  - Large number of items with multiple attributes changing over time
    - Economics, sensor networks
- Challenges
  - Overview of items showing *Interesting* temporal developments
  - Integrating multiple heterogeneous attributes of a collection of items
  - Multiple levels of temporal dynamics
- Solution?
  - ThermalPlot visualization technique!
    - Encoding changes in attributes into an item's position
      - Position based on a degree-of-interest (DOI) function

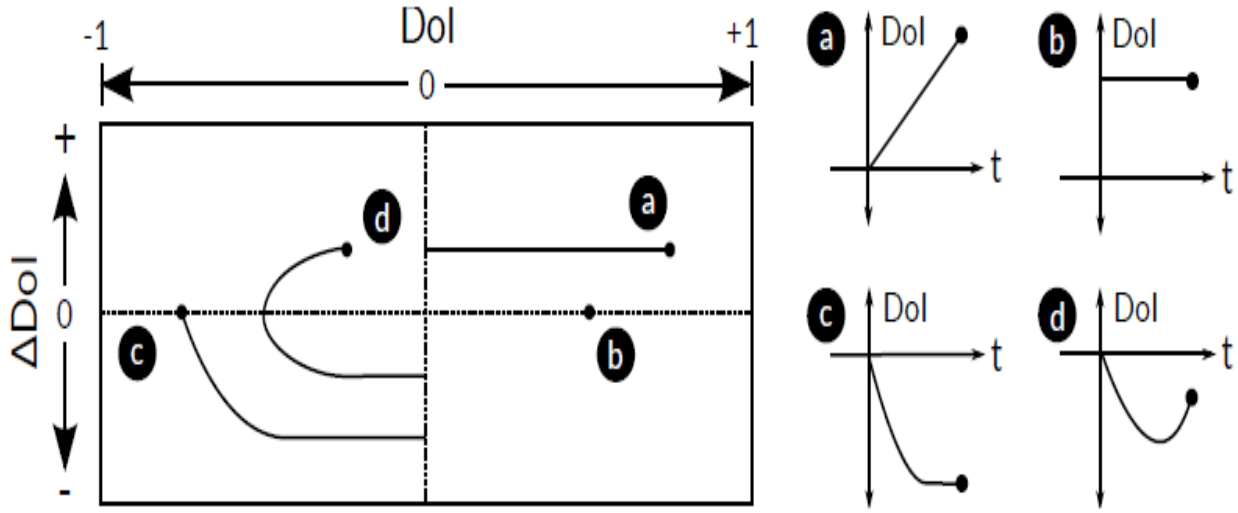
Previous work

- Multi-attribute item comparison
  - ➢ Across multiple attributes of a single item
  - ➢ Across a single attribute of multiple items
    - ✓ Superimposing multiple curves in a line chart
- Temporal dynamics
  - ➢ Mapping time to time
    - ✓ Animations, *Gapminder Trendalyzer*
  - ➢ Mapping time to space
    - ✓ *Cycle Plot*
    - ✓ Small multiples, *LiveRac*
  - ➢ Trajectories
    - ✓ *DimpVis*

ThermalPlot Concept

- Fundamental idea
  - ➢ User-specified degree-of-interest (DOI) value





Math behind the DOI

- DOI

$$DoI_{raw}(t) = \sum_{i=1}^{n} w_i \times v_i(t) \mid \sum_{i=1}^{n} w_i = 1.$$

$$DoI(t) = \alpha \times DoI_{raw}(t) + (1-\alpha) \times (DoI_{raw}(t-1) + DoI_{trend}(t-1)) .$$

$$DoI_{trend}(t) = \beta \times (DoI(t) - DoI(t-1)) + (1-\beta) \times DoI_{trend}(t-1).$$

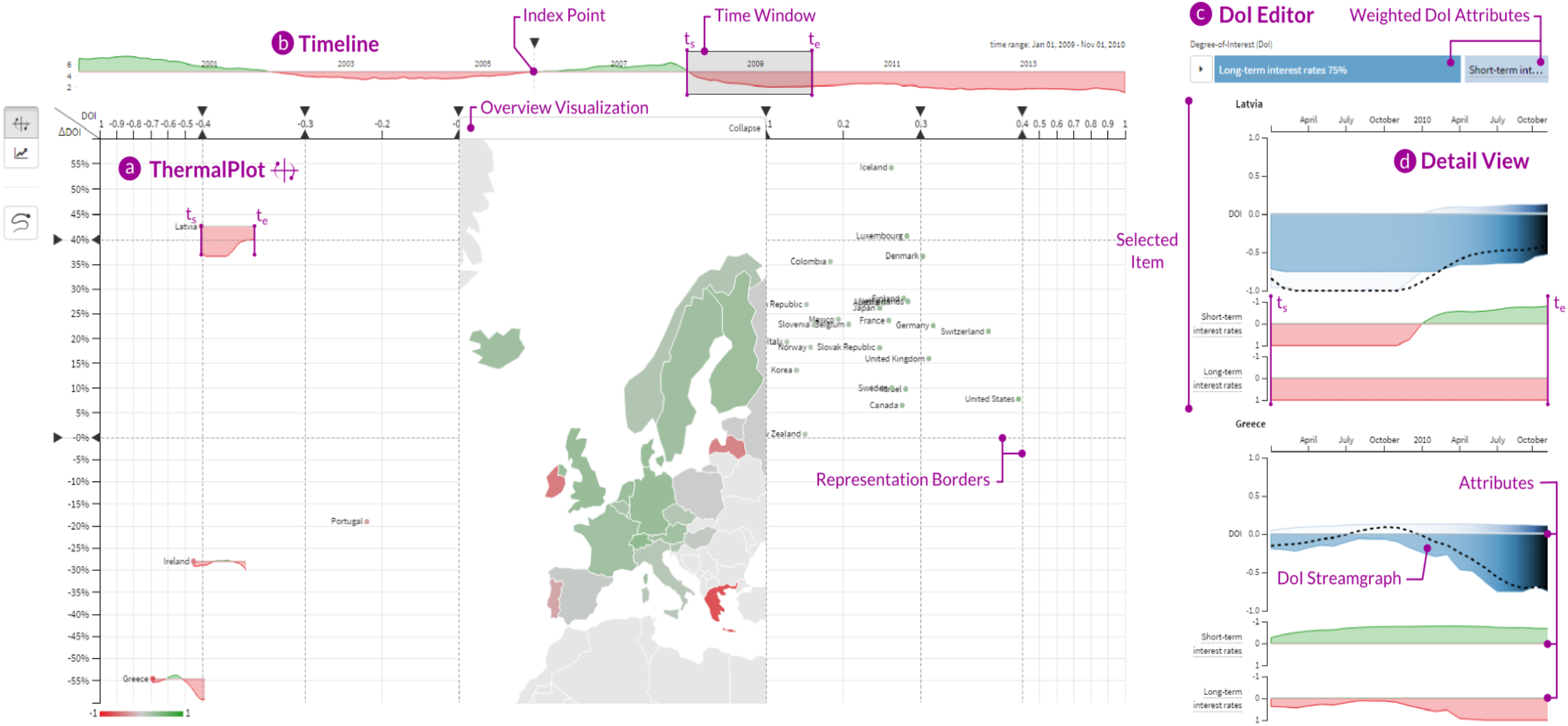
- Delta(DOI)

$$\Delta DoI(t) = DoI(t) - DoI(t-\Delta t).$$

- Normalization

$$v_{rel}(t) = \frac{v(t) - v(t_{index})}{v(t_{index})}.$$

- User tasks
  - Monitor the development of multiple items in a certain time window
  - Select attributes and define their interestingness
  - Detect items that are most interesting
  - Understand why the items are considered to be interesting
  - Monitor the development of a single item

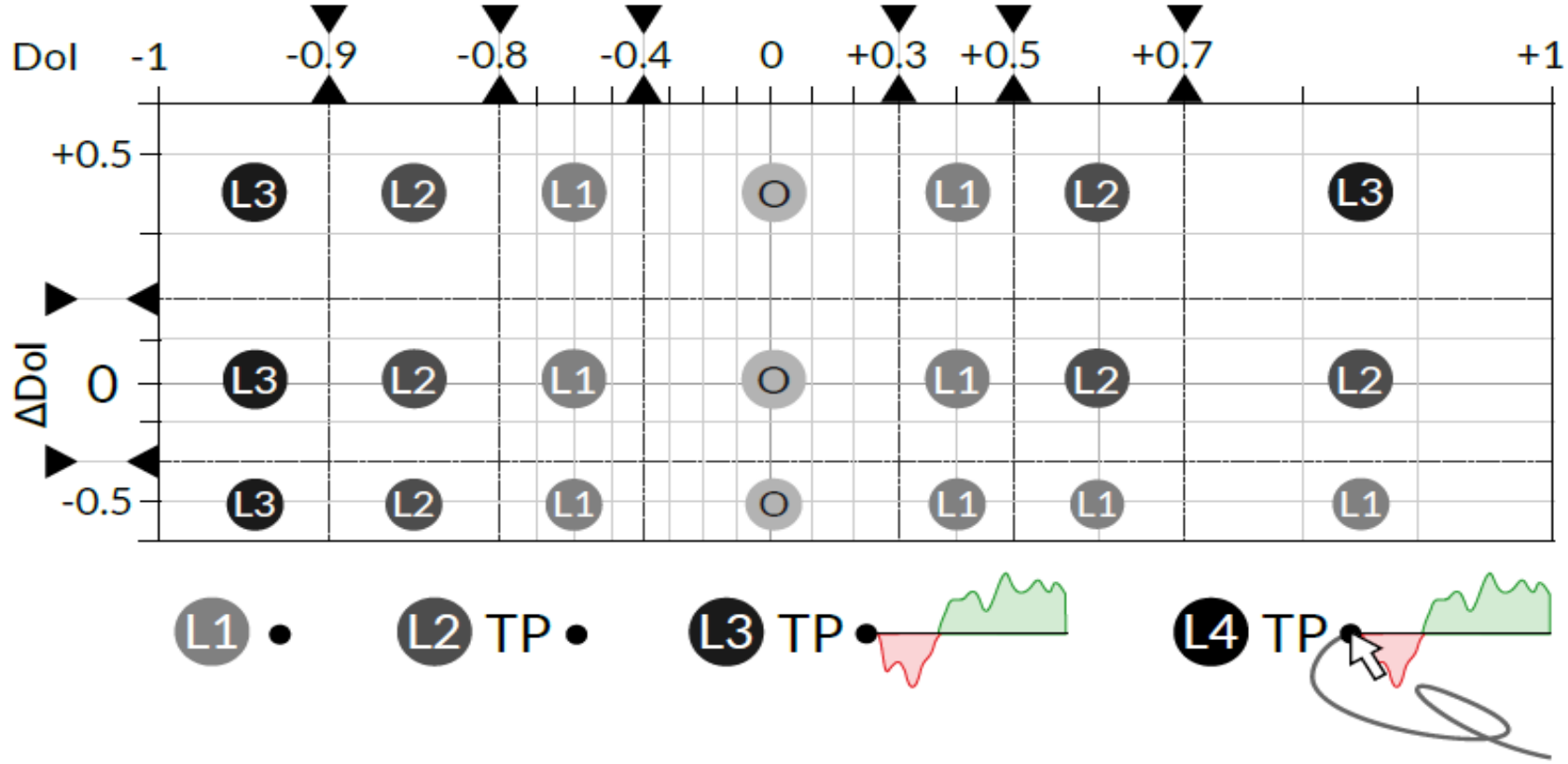

b Timeline
Index Point
Time Window
t_s
t_e
time range: Jan 01, 2009 - Nov 01, 2010
2001
2003
2005
2007
2009
2011
2013
Overview Visualization
DOI
ΔDOI
Collapse
a ThermalPlot
Latvia
Portugal
Ireland
Greece
Iceland
Luxembourg
Colombia
Denmark
Republic
Japan
Slovenia
Mexico
France
Germany
Switzerland
Norway
Slovak Republic
United Kingdom
Korea
Canada
United States
Zealand
Selected Item
Representation Borders
c DoI Editor
Weighted DoI Attributes
Degree-of-Interest (DoI)
Long-term interest rates 75%
Short-term int...
d Detail View
April
July
October
2010
Short-term interest rates
Long-term interest rates
Attributes
DoI Streamgraph

Problem?!

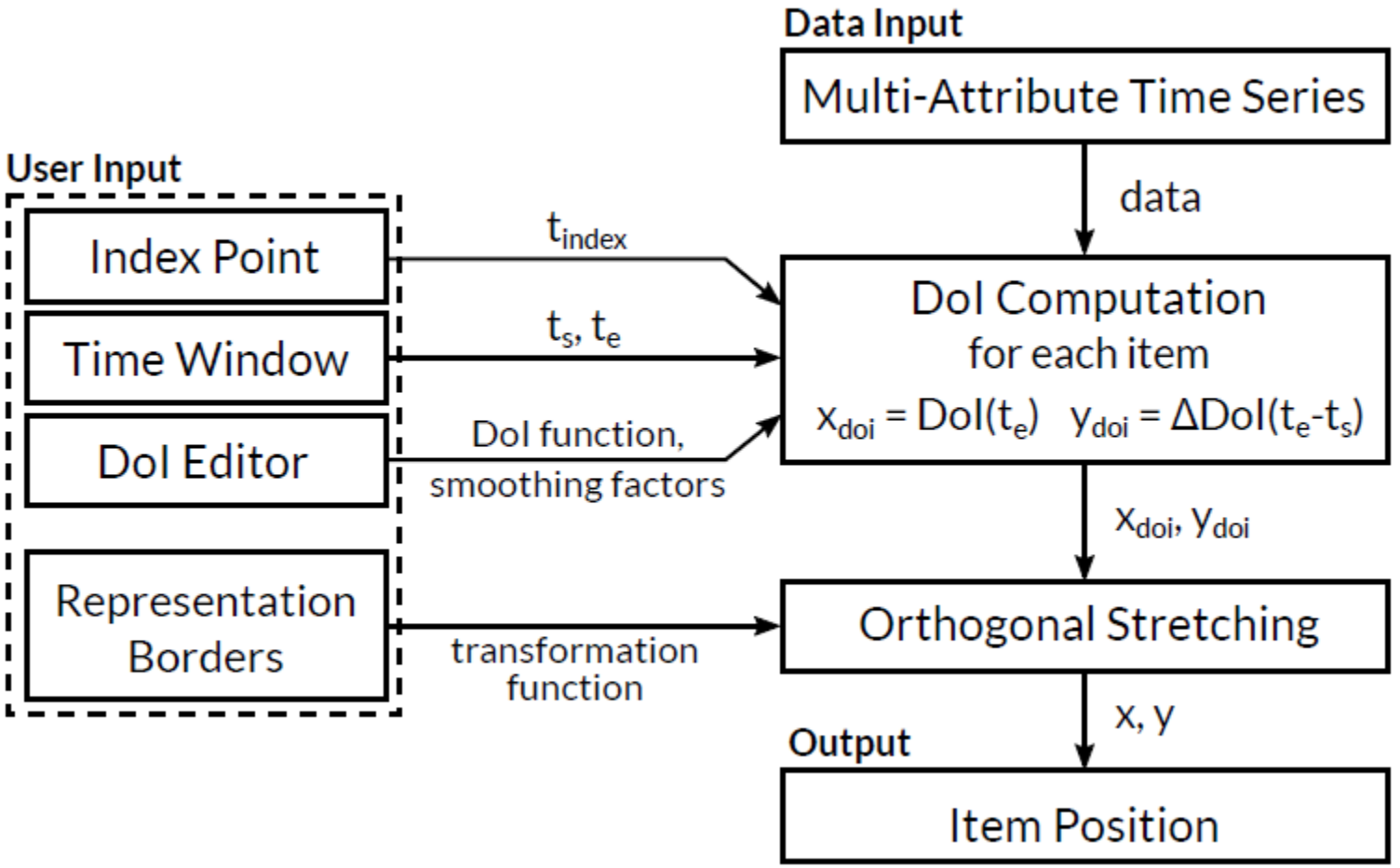

DOI
ΔDOI
1 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0 Collapse 1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
-0%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
-40%
-45%
-50%
-55%
Latvia
Portugal
Ireland
Greece
Iceland
Luxembourg
Colombia
Denmark
Republic
Japan
Slovenia
Mexico
France
Germany
Switzerland
Italy
Norway
Slovak Republic
United Kingdom
Korea
Canada
United States
Zealand

Clutter Reduction Strategies

- Semantic Zooming
- Orthogonal Stretching



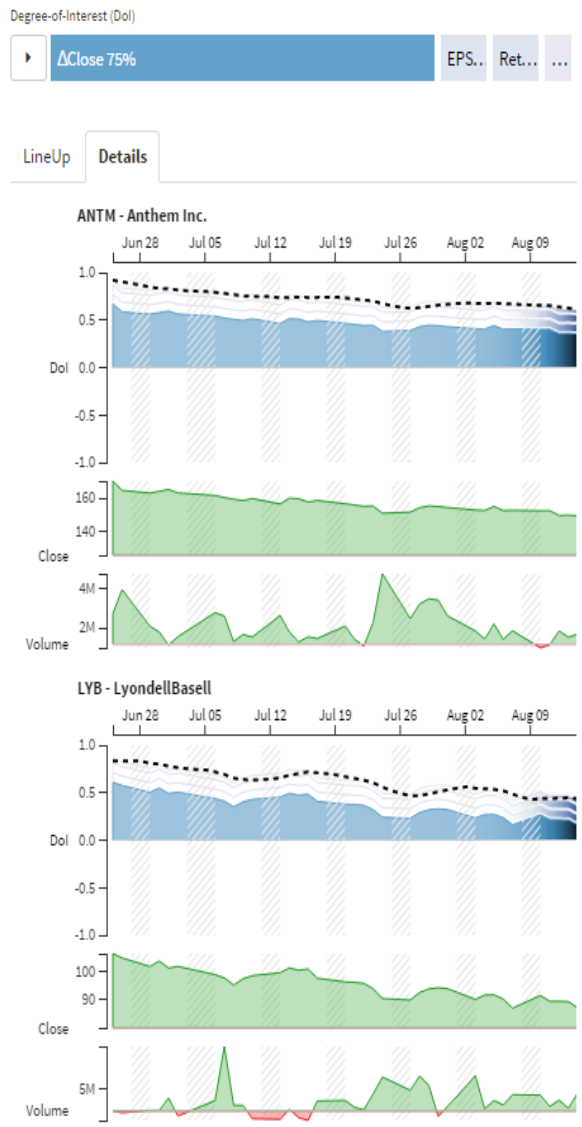
Data Flow


Data Input
Multi-Attribute Time Series
data
User Input
Index Point
Time Window
DoI Editor
Representation Borders
t_{index}
t_s, t_e
DoI function, smoothing factors
transformation function
DoI Computation for each item
x_{doi} = DoI(t_e) y_{doi} = ΔDoI(t_e-t_s)
x_{doi}, y_{doi}
Orthogonal Stretching
x, y
Output
Item Position

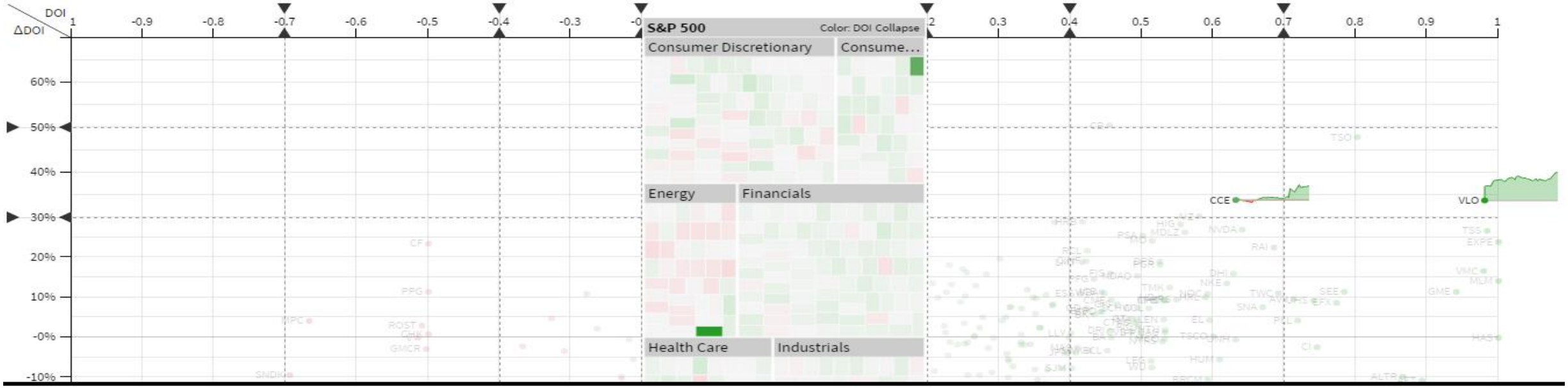
Use case

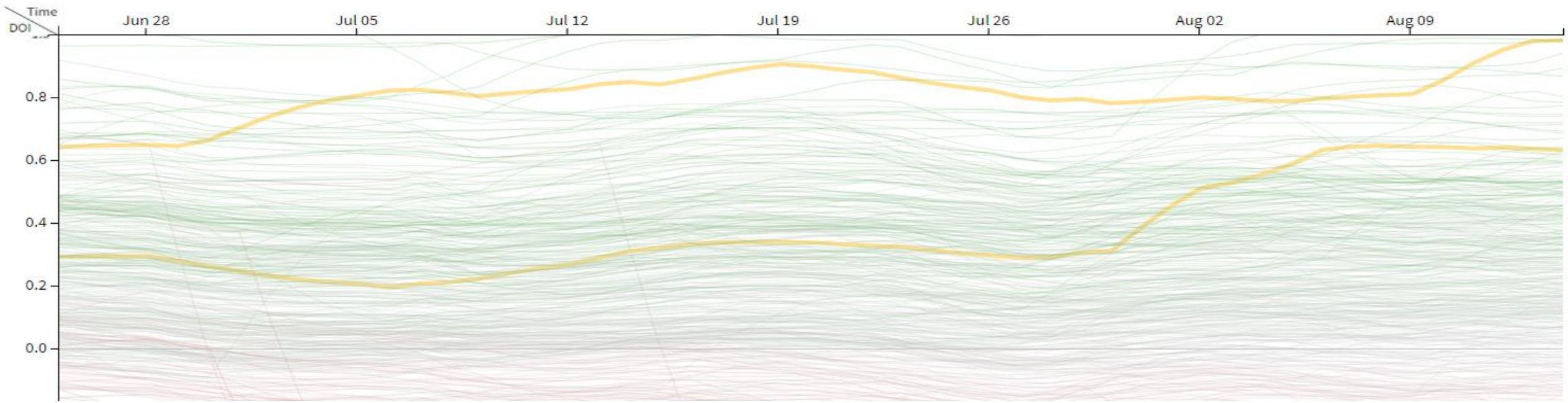

time range: Jun 25, 2015 - Aug 14, 2015
Degree-of-Interest (DoI)
ΔClose 75%
EPS..
Ret...
LineUp
Details
S&P 500
Color: DOI Collapse
Consumer Discretionary
Consume...
Energy
Financials
Health Care
Industrials
Information Technology
Teleco...
Utilities
Materials
DOI
ΔDOI
Rank
Industry
Ticker
Company
Combination
252 SYY Sysco Corp.
253 WEC Wisconsin Energy Corporation
254 BCR Bard (C.R.) Inc.
255 WY Weyerhaeuser Corp.
256 FTR Frontier Communications
257 VMC Vulcan Materials
258 WMB Williams Cos.
259 CERN Cerner
260 GRMN Garmin Ltd.
261 FB Facebook
262 RHT Red Hat Inc.
263 HCN Health Care REIT, Inc.
264 KMB Kimberly-Clark
265 SWN Southwestern Energy
266 HAL Halliburton Co.
267 SYK Stryker Corp.
268 BWA BorgWarner
269 WFM Whole Foods Market
270 HSP Hospira Inc.
271 DAL Delta Air Lines
272 PRGO Perrigo
273 TGT Target Corp.
274 CSX CSX Corp.
275 AA Alcoa Inc
276 OI Owens-Illinois Inc
277 MO Altria Group Inc
278 GME GameStop Corp.
279 WIN Windstream Communications
280 PCL Plum Creek Timber Co.
281 ESV Ensco plc
282 FSLR First Solar Inc
283 AMT American Tower Corp A
MPC
CHK
CNX
OKE
DO
CVX
ESV
NOV
HES
COP
COG
DNR
OEP
MRO
TSO
VLO
PSX
HAL
BHI
WMB


time range: Jun 25, 2015 - Aug 14, 2015
2,100
2,050
2,000
Jan 10
Jan 24
Feb 07
Feb 21
Mar 07
Mar 21
Apr 04
Apr 18
May 02
May 16
May 30
Jun 13
Jun 27
Jul 11
Jul 25
Aug 08
DOI
ΔDOI
S&P 500
Color: DOI Collapse
Consumer Discretionary
Consume...
Energy
Financials
Health Care
Industrials
Information Technology
Teleco...
Utilities
Materials
ANTM
LYB


Degree-of-Interest (DoI)
ΔClose 75%
EPS..
Ret...
LineUp
Details
ANTM - Anthem Inc.
Jun 28
Jul 05
Jul 12
Jul 19
Jul 26
Aug 02
Aug 09
DoI
Close
Volume
LYB - LyondellBasell


time range: Jun 25, 2015 - Aug 14, 2015
2,100
2,050
2,000
Jan 10
Jan 24
Feb 07
Feb 21
Mar 07
Mar 21
Apr 04
Apr 18
May 02
May 16
May 30
Jun 13
Jun 27
Jul 11
Jul 25
Aug 08
DOI
ΔDOI
1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
60%
50%
40%
30%
20%
10%
-0%
-10%
-20%
-30%
-40%
-50%
-60%
a Negative stocks with positive trend
b Positive stocks with positive trend
c Positive stocks with negative trend
d Negative stocks with negative trend
S&P 500
Color: DOI Collapse
Consumer Discretionary
Consume...
Energy
Financials
Health Care
Industrials
Information Technology
Teleco...
Utilities
Materials
CF
PPG
MPC
ROST
CHK
GMCR
SNDK
CNX
IRM
DO
AA
ESV
NOV
RL
GRMN
AMAT
NAVI
COP
NBL
JOY
DNR
RRC
VIAB
MRO
DAK
CB
TSO
CCE
VLO
HRB
AIZ
HIG
MDLZ
NVDA
PSA
MO
RAI
TSS
EXPE
VMC
MLM
DHI
NKE
TMK
NOC
HRL
TWC
SEE
GME
AVY
UHS
EFX
SNA
PLL
EL
LEN
LLY
TSCO
UNH
HAS
CI
HUM
BRCM
ALTR
AET
STJ
ZTS
DIS
ANTM
LYB
-1
1


DOI
ΔDOI
1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0
S&P 500
Color: DOI Collapse
Consumer Discretionary
Consume...
Energy
Financials
Health Care
Industrials
2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
60%
50%
40%
30%
20%
10%
-0%
-10%
CCE
VLO


Time
DOI
Jun 28
Jul 05
Jul 12
Jul 19
Jul 26
Aug 02
Aug 09
0.8
0.6
0.4
0.2
0.0

Analysis Summary

- What: data
  - Time-series, multiple attributes, multiple items
- What: derived
  - DOI and Delta(DOI) values based on user input
- How: encode
  - Item's position
  - Diverging colors
- How: Manipulate
  - Select
- How: Facet
  - Juxtapose
- How: Reduce
  - Focus+Context

- Why: Action
  - Discover
  - Browse
  - Identify
- Why: Target
  - Trends
  - Distribution

Critique

- Strength
  - Wise choice of item's position
  - Capability to handle large data sets
  - Use of overview and details on demand
- Weakness
  - No look-up scenarios anticipated
  - Animation for live data streaming
  - Adjusting the representation borders

THANKS !