



Figure 2: Graphical Model of NOC: In this figure, shaded and unshaded variables indicate observed and latent variables, respectively. An arrow indicates a conditional dependency between variables and stacked panes indicate a repeated sampling with the iteration number shown. $\theta_{z_{ji}}$ is associated with one ϕ_k via the topic indicator, k .

ing Twitter data¹, where we selected tweets from 30/08/2012 to 29/01/2013, and gained a corpus consisting of 65,456,988 users and 321,513,597 tweets. From this data set, we collected tweets including top 1000 most frequently mentioned hashtags and made latest 2-month time series for each hash tag, j , by counting the number of tweets on each day, w_{ji} , and aligning them on each hash tag. We set the cardinality of this data to 1000, and ran the experiments on 40 PCs with Hadoop² and Dual Core 2.66 GHz Xeon processors and the number of Gibbs sampling iterations was set to 1000.

Firstly, we used K -means clustering to evaluate the effect of coded representation, and phrases in the classification task, and measured the average cluster quality of them under $K=20$. Table 2 shows that phrases representation could reduce sensitivity to noise and fits for time series analysis, since clusters using phrases attain similarity values 1.20 times higher than clusters gained from raw time series.

Because value prediction is also one of most interesting tasks in time series data and this data is converted into codes with their probability, this task can be evaluated using the test-set perplexity (PPX), which is a standard measure in NLP to assess the predictive power of a model. To compare the generative ability of time series with HDP [5]-LDA [1], and N -gram topic models such as NTSeg [3], we computed PPX following the setting [4] using the averages of ten-fold cross validation, and show the result in Table 3. This table confirms our assumption that NOC could be applied to time series analysis through the appropriate coding approach, and could fit for modeling and explaining the generative process of time series, since it shows the lowest PPX.

4. CONCLUSION

Our contribution lies in evaluating and showing the effect of NLP techniques in the time series analysis. Future work is to extend this approach to reveal significant correlations between different time series.

¹Twitter: <http://twitter.com>

²ApacheTMHadoop®: <http://hadoop.apache.org/>

Table 1: Notation used in this paper

SYMBOL	DESCRIPTION
$D(W)$	#documents (vocabulary size)
$N_j(L_j)$	#words (topic level) in j -th document
$z_{ji}(l_{ji})$	the i -th topic (level) variable in j -th document
w_{ji}	the i -th word in j -th document
h_{ji}	the previous word sequence sharing with the same topic before w_{ji}
G_0	a $ W $ -dimensional uniform word distribution
$G_T(G_{T_j})$	the topic distribution of T (T_j)
$G_{T^l}(G_{T_j^l})$	the l -th level topic distribution of T (T_j)
$\phi_{l,p,c}(\phi_k)$	topic: the c -th child in l -th level of p -th parent topic in $l-1$ level (shorthand of $\phi_{l,p,c}$)
\mathbf{u}	a $n-1$ words sequence sharing the same topic
G_k^u	the topic k specific word distribution following \mathbf{u}
$d_{ u }(\gamma_{ u })$	the $ u $ specific discount (concentration): parameter $d_{ u } \sim \text{Beta}(e_{ u }, f_{ u })$ ($\gamma_{ u } \sim \text{Gamma}(g_{ u }, h_{ u })$)
λ_{jl}	the l -th topic level of T_j specific beta random: variable $\lambda_{jl} \sim \text{Beta}(\delta_1, \delta_2)$
β_j	the j specific parameters: $\beta_{jl} \sim \text{Gamma}(a_1, a_2)$

Table 2: Performance quality comparison over time series with various representation: #topics is automatically defined as 57 from a given data. Code1, code2, and code3 means the code representation using NOC with only unigram, unigram+2-gram ($N<3$), and unigram+2,3-gram ($N<4$). Results that differ significantly, t-test $p < 0.01$, from the “raw” are marked with ‘*’.

data representation	raw	code1	code2	code3
average accuracy	0.483	0.612*	0.633*	0.652*

Table 3: PPX comparison over symbolic presentation time series: #topics of NTSeg is in tune with that of HDP-LDA. Results that differ significantly, t-test $p < 0.01$, from the “NTSeg”.

topic model	HDP-LDA	NTSeg	NOC
PPX	1324	1311	1123

5. REFERENCES

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