

Beyond Social Fragmentation Coexistence of Cultural Diversity and Structural Connectivity Is Possible with Social Constituent Diversity

HIROKI SAYAMA^{1,2} AND JUNICHI YAMANOI² ¹ BINGHAMTON UNIVERSITY, ² WASEDA UNIVERSITY

SAYAMA@BINGHAMTON.EDU





Post-Merger Cultural Integration from a Social Network Perspective: A Computational Modeling Approach



More from Complex Systems

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Post-Merger Cultu... Complex Systems



Optimization Prop... Complex Systems



Accelerating Disco... Complex Systems

Center for Collective Dynamics X KAKEN — Research Projects | H × + 🕼 🛛 🔒 https://kaken.nii.ac.jp/en/grant/KAKENHI-PROJECT-19H04220/ ... ⊠ ☆ Q Search G 133% KAKEN Search Research Projects Search Researchers How to Use English How does diversity of individuals affect the structure of society?: A constructive **Research Project** approach using adaptive networks **Project/Area Number** 19H04220 All Research Category Grant-in-Aid for Scientific Research (B) Allocation Type Single-year Grants Section 一般 Basic Section 62020:Web informatics and service informatics-related **Review Section Research Institution** Waseda University Principal Investigator 佐山 弘樹 早稲田大学, 商学学術院, 教授(任期付) (30345425) Co-Investigator(Kenkyū-buntansha) 山野井 順一 早稲田大学, 商学学術院, 准教授 (20386543)

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Project Status

Project Period (FY)

Granted (Fiscal Year 2019)

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Keywords

社会ネットワーク / 適応的ネットワーク / 多様性 / ネットワークデータ解析 / 計算モデル

Outline of Research at the Start 情報化・ネットワーク化の進んだ現代社会において、社会ネットワークがどのように動的に変化しているのかを理解し、効果的に運営・管理することは極めて重要な課題である.既存研究ではしばしば社会の構成要素が同質であると仮定され、実社会が持つ個の多様性は積極的に考慮されてこなかった.本研究では「適応的ネットワーク」という独自の枠組みを用い、個の性質に多様性を導入した数理モデルを構築する.モデルのパラメータ値は実社会ネットワーク時系列データの解析から推定する.以上を用いた大規模計算実験により個の多様性と社会構造との関連を明らかにし、従来理論では予言されなかった「多様性と接続性が共存する社会」の可能性を探る.

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Beyond Social Fragmentation: Coexistence of Cultural Diversity and Structural Connectivity Is Possible with Social Constituent Diversity

Hiroki Sayama^{1,2} and Junichi Yamanoi¹

¹ Waseda Innovation Lab, Waseda University, Shinjuku, Tokyo 169-8050, Japan ² Center for Collective Dynamics of Complex Systems, Binghamton University, Binghamton NY 13902-6000, USA sayama@binghamton.edu

Abstract. Social fragmentation caused by widening differences among constituents has recently become a highly relevant issue to our modern society. Theoretical models of social fragmentation using the adaptive network framework have been proposed and studied in earlier literature, which are known to either converge to a homogeneous, well-connected network or fragment into many disconnected subnetworks with distinct states. Here we introduced the diversities of behavioral attributes among social constituents and studied their effects on social network evolution. We investigated using a networked agent-based



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Objective



Adaptive Social Network Dynamics



Adaptive Social Network Dynamics





Adaptive Social Network Dynamics

Social Fragmentation Transition



Research Question



What We Did

Existing models in the literature assumed **behaviorally homogeneous**, identical agents

Make the agents behaviorally heterogeneous and see what happens

Model

Cultural Integration Model (Yamanoi & Sayama, 2013)

Each node (individual) has a cultural state

• A vector in an *m*-dimensional cultural space



Cultural space (e.g., *m*=2)

Cultural Propagation (Dynamics *on* Networks)

A node selects information source from its neighbors using link weights as probabilities

 With a small chance (1%) to pick a random node

Based on cultural distance, it may "accept" the source's culture

$$v_i \to (1 - r_s)v_i + r_s v_j$$



Link Weight Updates (Dynamics *of* Networks)

Link weight will increase (decrease) upon acceptance (rejection)

$$w_{ij} \rightarrow \text{logistic}(\text{logit}(w_{ij}) \pm r_w)$$

 Link disappears if weight gets too small (< 0.01)



Demo

Python + NetworkX



Experiments

Behavioral Parameters

- Cultural tolerance d
- Rate of cultural state change r_s
- Rate of edge weight change r_w

$$P_A = \left(\frac{1}{2}\right)^{\frac{|v_i - v_j|}{d}}$$

$$v_i \rightarrow (1 - r_s)v_i + r_s v_j$$

 $w_{ij} \rightarrow \text{logistic}(\text{logit}(w_{ij}) + r_w)$

Experimental Settings

Initial condition: two culturally distinct subnetworks connected to each other by random ties

Parameters d, r_s , r_w : Mean set to 0.5; **s.d. varied 0~0.5**

100 replications of simulation for each parameter value



Outcome Measures

<CD>: average cultural difference b/w original two subnetworks

<SPL>: average shortest path length

• (*<CD>*, *<SPL>*) = (high, high) => social fragmentation

(<CD>, <SPL>) = (low, low)
 => loss of cultural diversity

Results



High s.d.-of-*d* areas showed (*<CD>*, *<SPL>*) = (high, low) behavior that was not previously reported



Not So Much Effect of s.d. of r_s or r_w



Interactions on <CD>



Interactions on <*SPL*>



Regression Analysis of <*CD*>

$<CD> \sim 1.87262 + 3.01908 \sigma d + 2.97431 \sigma r_s - 2.72074 \sigma r_w - 8.95723 \sigma d \sigma r_s + 3.60938 \sigma d \sigma r_w + 3.90939 \sigma r_s \sigma r_w$

	Sum of		Mean		
	Squares	df	Square	F	Sig.
σd	1782.60	1	1782.60	9797.94	p<.0001
σr_s	1847.26	1	1847.26	10153.30	p<.0001
σr_w	445.64	1	445.64	2449.42	p<.0001
$\sigma d \sigma r_s$	1474.26	1	1474.26	8103.16	p<.0001
$\sigma d \sigma r_w$	239.38	1	239.38	1315.75	p<.0001
$\sigma r_s \sigma r_w$	280.83	1	280.83	1543.57	p<.0001
Error	3928.56	21593	0.18		
Total	9998.54	21599			

Regression Analysis of <*SPL*>

$\langle SPL \rangle \sim 2.31216 - 0.624629 \ \sigma d + 0.0989771 \ \sigma r_s - 0.178676 \ \sigma r_w - 0.390949 \ \sigma d \ \sigma r_s + 0.35265 \ \sigma d \ \sigma r_w + 0.122775 \ \sigma r_s \ \sigma r_w$

	Sum of		Mean		
	Squares	df	Square	F	Sig.
σd	253.02	1	253.02	58391.20	p<.0001
σr_s	0.64	1	0.64	148.78	p<.0001
σr_w	2.26	1	2.26	521.21	p<.0001
$\sigma d \sigma r_s$	2.80	1	2.80	646.91	p<.0001
$\sigma d \sigma r_w$	2.28	1	2.28	526.55	p<.0001
$\sigma r_s \sigma r_w$	0.28	1	0.28	63.83	p<.0001
Error	93.47	21571	0.00		
Total	354.75	21577			

Regression Analysis (Combined)

 $<CD> \sim 1.87262$ + $3.01908 \sigma d$ + $2.97431 \sigma r_s - 2.72074 \sigma r_w$ - $8.95723 \sigma d \sigma r_s + 3.60938 \sigma d \sigma r_w + 3.90939 \sigma r_s \sigma r_w$

 $\langle SPL \rangle \sim 2.31216$ - $0.624629 \sigma d + 0.0989771 \sigma r_s - 0.178676 \sigma r_w$ $- 0.390949 \sigma d \sigma r_s + 0.35265 \sigma d \sigma r_w + 0.122775 \sigma r_s \sigma r_w$

Conclusions

Diversity of cultural tolerance helps coexistence of cultural diversity and structural connectivity => innovation in society?

- Heterogeneity of entities is crucial for understanding complex systems
- Behavioral diversity, not superficial diversity
- Not just tolerance, but diverse levels of tolerance

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