KEIO UNIVERSITY



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# Grouping States: Community Detection Methods in International Relations


## ABSTRACT

In the field of International Relations, grouping states is one of the popular ways to understand the situation of international society. In general, researchers in International Relations categorize countries by their political system, economy size, military power, cultural similarity, and geographical contiguity. However, although those are useful categories in some cases, they do not necessarily mean cooperative relationship or common interests among states of the same group. One reason for this is because those criteria are not much involved in relational factors between states.

This study tries to apply the community detection method of Social Network Analysis (SNA) to the field of International Relations. In recent years, community detection methods are greatly developed by network analysis researchers. However, few researchers in International Relations have paid much attention to this mathematical method. To consider how SNA's community detection method can be applied to IR studies is the main aim of this research.

In order to calculate so called political affinity between states, this research uses the data of voting behaviors in the United Nations General Assembly (UNGA). It enables long-term and periodical analysis on the transition of international community structure, especially comparing the periods during and after the Cold War. Also, since community structures differ with the realm of politics, the research picks out three important themes based on UNGA agendas: arms control and disarmament, human rights, and third world. The analysis on these different political realms reveals complex and multi-layered characteristics of international community.


## 1. THE AIM OF THIS RESEARCH

The main aim of this research is just to examine and propose how SNA's community detection method can be applied to the field of International Relations. Thus, it is not destined to prove the superiority of SNA's community detection method to the other ones: direct factor analysis, cluster analysis, etc.

## 2. RELATED STUDIES (Table 2-1)

- Studies on international community detection were raised in the late 1960s [1][2][3][4], but after then ignored for long time.
- A Study by Traag et al. [5] is an exception to apply SNA's community detection method to IR. Yet, it mainly focuses on the proposal of a new community detection method, not the analysis of international society itself.

Table 2-1. List of related studies

| No | author(s) | year | method | data types | data period |
|---|---|---|---|---|---|
| [1] | Brams | 1966 | hierarchical decomposition | diplomatic exchanges, trade, IGO shared memberships | 1962-64 |
| [2] | Brams | 1969 | triad analysis | diplomatic exchanges | 1964-65 |
| [3] | Russett | 1968 | direct factor analysis | trade | 1938-63 |
| [4] | Russett | 1969 | direct factor analysis | diplomatic exchanges | 1963-64 |
| [5] | Traag, et al. | 2009 | spin glass algorithm | military alliances, conflicts | 1993-2001 |

## 3. METHOD

- Modularity (Q) is a criterion designed to measure the strength (suitability) of a detected community structure:

$$Q = \sum_i (e_{ii} - a_i^2)$$

$$e_{ij} = \sum_{r \in C_i} \sum_{s \in C_j} \frac{A_{rs}}{2m} \qquad a_i = \sum_{r \in C_i} \frac{k_r}{2m}$$

A: Adjacency matrix

$$A_{rs} = \begin{cases} 1 \ldots \text{any edges between r and s} \\ 0 \ldots \text{otherwise} \end{cases}$$

m: the number of all edges' hands

$k_r$: degree of vertex r

- Modularity calculates relative density of edges inside communities to between (see **Figure 3-1**).
- Modularity maximization is NP-completeness (i.e. the time required to find the exact solution increases very quickly as the size of the problem grows).
- Heuristics are basic methods to maximize modularity (=detect community structure). See. **Table 3-1**.
- This research applies the all methods listed in Table 3-1, then selects one with largest modularity.

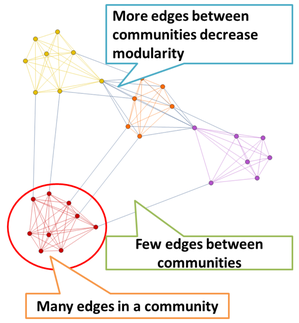



Figure 3-1 Sample network and modularity

Table 3-1 Heuristics for community detection

| Method | Author(s) | year |
|---|---|---|
| edgebetweenness centrality | Newman and Girvan | 2004 |
| random walk | Pons and Latapy | 2006 |
| greedy algorithm | Clauset, et al. | 2004 |
| eigenvector | Newman | 2006 |
| multi-level optimization | Newman | 2004 |

## 4. DATA

- Voting behaviors in the United Nations General Assembly (UNGA) is available on UNBISnet, the official online library of the United Nations (only votes approved).
- **Table 4-1** shows information of the data.
- The raw data of each voting behavior in agenda (t) is translated into the affinity relationship between state i and j ($s_{ij}(t)$) by using an allocation matrix (see **Table 4-2**).
- The average of $s_{ij}(t)$ is the element of adjacency matrix (S):

$$S_{ij} = \frac{1}{T} \times \sum_{t \in T} s_{ij}(t)$$

- S is translated into 0-1 adjacency matrix A by threshold θ :

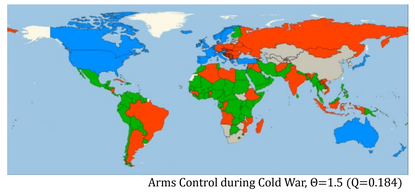
$$A_{ij} = \begin{cases} 1 & \text{if } S_{ij} \geq \theta \\ 0 & \text{if } S_{ij} < \theta \end{cases}$$

Table 4-1 Number of samples

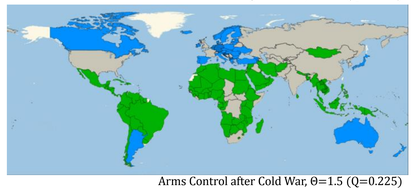
| | during Cold War 1945-1989 | after Cold War 1990-2014 |
|---|---|---|
| arms control and disarmament | 504 | 467 |
| human rights | 766 | 117 |
| third world | 462 | 412 |

Table 4-2 Allocation matrix

| state A \ state B | Yea | Nay | Abstain | Absence /Missing |
|---|---|---|---|---|
| Yea | 2 | -2 | -1 | 0 |
| Nay | -2 | 2 | 1 | 0 |
| Abstain | -1 | 1 | 2 | 0 |
| Absence/Missing | 0 | 0 | 0 | 0 |

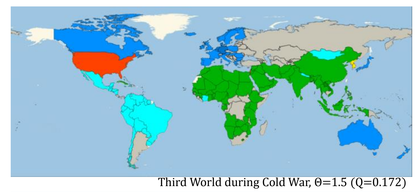


Arms Control during Cold War, Θ=1.5 (Q=0.184)

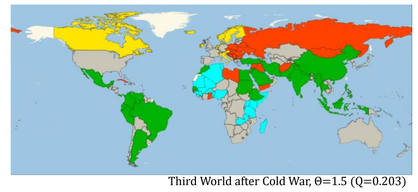


Arms Control after Cold War, Θ=1.5 (Q=0.225)

Figure 5-1 Arms control and disarmament

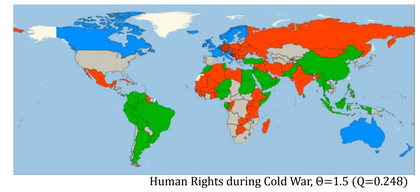


Third World during Cold War, Θ=1.5 (Q=0.172)

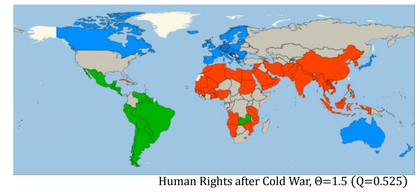


Third World after Cold War, Θ=1.5 (Q=0.203)

Figure 5-2 Third world



Human Rights during Cold War, Θ=1.5 (Q=0.248)



Human Rights after Cold War, Θ=1.5 (Q=0.525)

Figure 5-3 Human rights

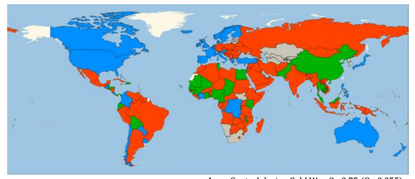
## 5. RESULTS & DISCUSSION

◆ Arms control disarmament (**Figure 5-1**)
- Community structure was based on East, West, and Third World during the Cold War.
- Former East bloc loses its coalition after the Cold War, while West countries largely keeps their ties.

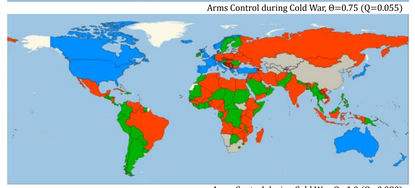
◆ Third world (**Figure 5-2**)
- West bloc and developing countries were main communities, while the U. S. was alone only with Israel during CW.
- After CW, complicated structure appears (West lose its coalition).

◆ Human rights (**Figure 5-3**)
- East, West, Third World (during CW). Many African countries were incorporated into East bloc.
- East loses its tie, Latin America is detected as an independent community after CW.

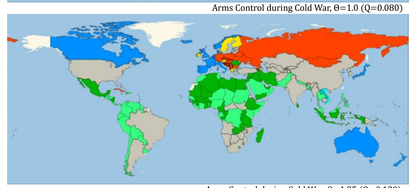
◆ Threshold Test (**Figure 5-4**)
- The higher threshold value θ becomes, the fewer edges are recognized in a network.
- While the detail of community structure is changed, basic structure (East, West, Third World) is robust.



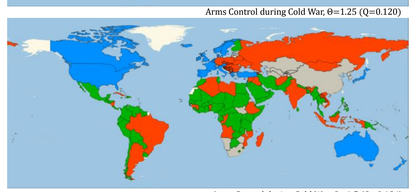
Arms Control during Cold War, Θ=0.75 (Q=0.055)



Arms Control during Cold War, Θ=1.0 (Q=0.080)



Arms Control during Cold War, Θ=1.25 (Q=0.120)



Arms Control during Cold War, Θ=1.5 (Q=0.184)

Figure 5-4 Threshold Examination

## 6. CONCLUSION & FUTURE WORK

- Multiple layers of international community are detected and their transitions are visualized by SNA's community detection method.
- Applying this method to other kinds of data (formal alliance, trade, etc.) may cast light on some new aspects of International Relations.
- Applying this method to weighted (valued) graphs is required.

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