Intelligent Software Systems Lab
KYUNGPOOK NATIONAL UNIVERSITY

번개 발표

# 그래프신경망을 활용한 이상 징후 탐지 연구

## GNN model-based Anomaly Detection using Disaster Knowledge Graph

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## Background & Problem

- The frequency of disaster occurrences is increasing, resulting in more ***property losses and casualties***.
- Understanding and analyzing the relationship between *structured and unstructured* ***data related to disasters with different sources and formats*** is essential.

## Purpose

- Generate ***time-series disaster knowledge graphs*** to understand the flow of disasters and ***detect anomalies***.
- Understand the disaster patterns for searching ***similar disasters*** through graph machine learning.

## System Overview

- Generate knowledge graph with the relationship between data ***based on location and time*** of the generation.
- Perform ***risk calculation and pattern analysis*** with graphs stored in in-memory database.
- Apply ***Graph Neural Network(GNN) models*** with graphs.
- Establish a strategy to detect and respond to disasters.

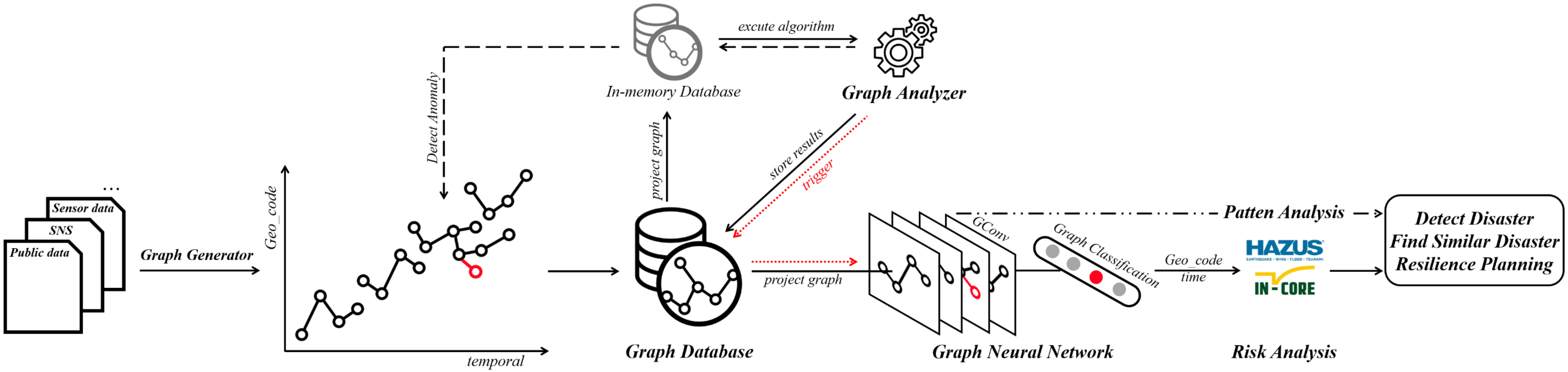
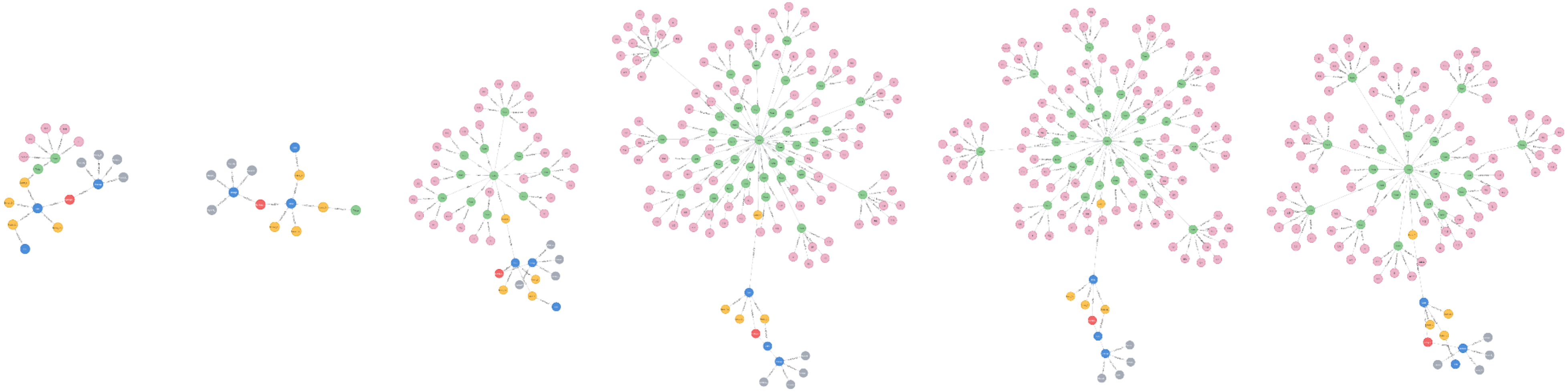



Fig. System Analysis Process

## Time-series Disaster Knowledge Graph Generation

M. 1.9 earthquake on April 8, 2023, around 9:44 a.m., in Daejeon, Korea.



09:42:00~09:43:00 09:43:00~09:44:00 **09:44:00~09:45:00** 09:45:00~09:46:00 09:46:00~09:47:00

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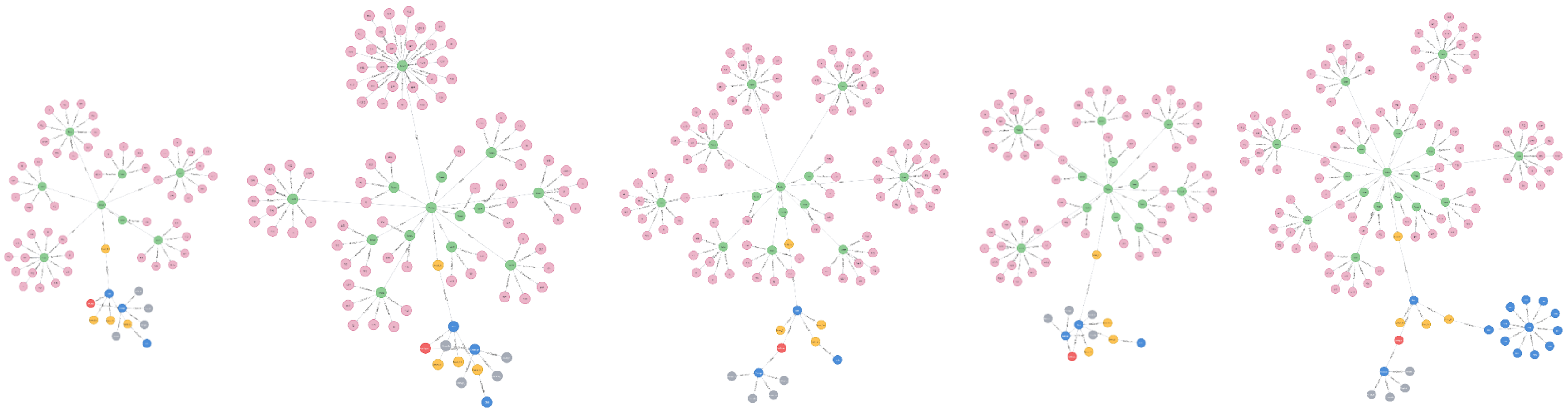

10:02:00~10:03:00 10:03:00~10:04:00 10:04:00~10:05:00 10:05:00~10:06:00 **10:06:00~10:07:00**

## Graph Convolutional Network, GCN

- The ***degree centrality*** and ***attribute values*** of each graph node and edge can be expressed in the form of a vector through vector embedding.
- Outputs probability distributions for input graphs and ***determines final classification***.

## SAmple and aggreGatE, GraphSAGE

- It leverages aggregating information from ***local and global neighborhoods***, enabling effective representation learning for graph classification.
- Performs ***multiple iterations*** of the update rule to refine node representations.

## Graph ATtention network, GAT

- It allows each node to ***weigh the importance of its neighbors*** during information propagation.
- Train the model ***with weights*** between nodes.

## Dataset

- ***Select 50 earthquakes*** to generate disaster knowledge graphs (Ten-year period from 2013 to 2023, Scale $\geq$ 3.0, Magnitude $>$ 1.0)
- Generate ***120 graphs for each earthquake*** at 1-minute intervals for an hour before and after.
- Set ***label*** to dataset.
  - '$non\_eq$' : graphs created prior to the earthquake.
  - '$eq$' : graphs correspond to when the earthquake occurred with fore/after shock.
  - '$after\_eq$' : graphs up to 10 minutes after the earthquake.

Tab. Graph Dataset

| M. | Scale | Number of | | | | | |
|---|---|---|---|---|---|---|---|
| | | Disaster | Graphs | Nodes | Edges | '$eq$' | '$non\_eq$' |
| $> 1$ | $\geq 3$ | 40 | 4800 | 524841 | 524840 | 1025 | 3775 |

## Results

- Model Performance results (75% train dataset, 20% test dataset, 5% validation dataset.)

| Model | TP | FP | TN | FN | Acc. | Pre. | Recall | F1-score |
|---|---|---|---|---|---|---|---|---|
| GCN | 70 | 8 | 747 | 135 | 85.10 | 87.22 | 66.54 | 70.37 |
| GSG | 80 | 33 | 722 | 125 | 83.54 | 78.02 | 67.33 | 70.23 |
| GAT | 67 | 14 | 740 | 138 | 84.06 | 82.99 | 65.35 | 68.66 |
| K-means | 69 | 17 | 738 | 136 | 84.06 | 82.34 | 65.70 | 69.02 |

- Disaster Detection Results

| Model | 1-min | 2-min | 3-min | Over 4-min | Non-detected |
|---|---|---|---|---|---|
| GCN | 30% | 50% | 0% | 10% | 10% |
| GSG | 40% | 40% | 10% | 10% | 0% |
| GAT | 30% | 20% | 0% | 40% | 10% |
| K-means | 30% | 50% | 0% | 20% | 0% |

## Contribution to ERC

- **Anomaly Detection & Pattern Analysis**
  - Create knowledge graphs ***using system monitoring data*** in time-series.
  - Analyze the patterns of monitoring data to ***detect anomaly*** in system.

## Future Work

- **Pattern Analysis & Classify Similar Disaster**
  - Analyze disaster patterns to detect and ***classify similar disasters***.
  - Search disasters similar to past disasters and establish ***recovery strategies***.

# Thank you

## Q & A