I**NTRODUCTION:**

With the emergence of artificial intelligence (AI) techniques, learning-based approaches for detecting cyber attacks, have become further improved, and they have achieved significant results in many studies. However, owing to constantly evolving cyber attacks, it is still highly challenging to protect IT systems against threats and malicious behaviors in networks. Because of various network intrusions and malicious activities, effective defenses and security considerations were given high priority for finding reliable solutions [1], [2], [3], [4].

Traditionally, there are two primary systems for detecting cyber-threats and network intrusions. An intrusion prevention system (IPS) is installed in the enterprise network, and can examine the network protocols and flows with signature-based methods primarily. It generates appropriate intrusion alerts, called the security events, and reports the generating alerts to another system, such as SIEM. The security information and event management (SIEM) has been focusing on collecting and managing the alerts of IPSs. The SIEM is the most common and dependable solution among various security operations solutions to analyze the collected security events and logs [5]. Moreover, security analysts make an effort to investigate suspicious alerts by policies and threshold, and to discover malicious behavior by analyzing correlations among events, using knowledge related to attacks.

Nevertheless, it is still difficult to recognize and detect intrusions against intelligent network attacks owing to their high false alerts and the huge amount of security data [6], [7]. Hence, the most recent studies in the field of intrusion detection have given increased focus to machine learning and artificial intelligence techniques for detecting attacks. Advancement in AI fields can facilitate the investigation of network intrusions by security analysts in a timely and automated manner. These learning-based approaches require to learn the attack model from historical threat data and use the trained models to detect intrusions for unknown cyber threats [8], [9].

A learning-based method geared toward determining whether an attack occurred in a large amount of data can be useful to analysts who need to instantly analyze numerous events. According to [10], information security solutions generally fall into two categories: analyst-driven and machine learning-driven solutions. Analyst-driven solutions rely on rules determined by security experts called analysts. Meanwhile, machine learning-driven solutions used to detect rare or anomalous patterns can improve detection of new cyber threats [10]. Nevertheless, while learning-based approaches are useful in detecting cyber attacks in systems and networks, we observed that existing learning-based approaches have four main limitations.

First, learning-based detection methods require labeled data, which enable the training of the model and evaluation of generated learning models. Furthermore, it is not straightforward to obtain such labeled data at a scale that allow accurate training of a model. Despite the need for labeled data, many commercial SIEM solutions do not maintain labeled data that can be applied to supervised learning models [10].

Second, most of the learning features that are theoretically used in each study are not generalized features in the real world, because they are not contained in common network security systems [3]. Hence, it makes difficult to utilize to practical cases. Recent efforts on intrusion detection research have considered an automation approach with deep learning technologies, and performance has been evaluated using wellknown datasets like NSLKDD [11], CICIDS2017 [12], and Kyoto-Honeypot [13]. However, many previous studies used benchmark dataset, which, though accurate, are not generalizable to the real world because of the insufficient features. To overcome these limitations, an employed learning model requires to evaluate with datasets that are collected in the real world.

Third, using an anomaly-based method to detect network intrusion can help detect unknown cyber threats; whereas it can also cause a high false alert rate [6]. Triggering many false positive alerts is extremely costly and requires a substantially large amount of effort from personnel to investigate them.

Fourth, some hackers can deliberately cover their malicious activities by slowly changing their behavior patterns [10], [14]. Even when appropriate learning-based models are possible, attackers constantly change their behaviors, making the detection models unsuitable. Moreover, almost all security systems have been focused on analyzing short-term network security events. To defend consistently evolving attacks, we assume that over long-term periods, analyzing the security event history associated with the generation of events can be one way of detecting the malicious behavior of cyber attacks.

These challenges form the primary motivation for this work. To address these challenges, we present an AI-SIEM system which is able to discriminate between true alerts and false alerts based on deep learning techniques.

Our proposed system can help security analysts rapidly to respond cyber threats, dispersed across a large amount of security events. For this, the proposed the AI-SIEM system particularly includes an event pattern extraction method by aggregating together events with a concurrency feature and correlating between event sets in collected data. Our event profiles have the potential to provide concise input data for various deep neural networks. Moreover, it enables the analyst to handle all the data promptly and efficiently by comparison with longterm history data.