# Prospects of Artificial Intelligence in Tackling Cyber Crimes

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**Abstract:** *As we are living in an interconnected online world, most of our everyday communications and commercial activities now take place via the Internet. Since cyber infrastructure is highly vulnerable to attacks, the threats in cyber space move at the speed of light. With the speed of cyber activity and high volume of data used, the protection of cyber space cannot be handled by any physical device or by human intervention alone. It needs considerable automation to detect threats and to make intelligent real-time decisions. It is difficult to develop software with conventional algorithms to effectively protect against the dynamically evolving attacks. It can be tackled by applying bio inspired computing methods of artificial intelligence to the software. The purpose of this study is to explore the possibilities of artificial intelligence in addressing the cybercrime issues.*

**Keywords:** Artificial Intelligence, Artificial Neural Network, Artificial Immune System, Intelligent Agents, Genetic Algorithm, Fuzzy, Cyber Crime, Intrusion Detection and Prevention Systems.

## 1. Introduction

As we are living in an interconnected online world, most of our everyday communications and commercial activities now take place via the Internet. Growing trends of internet computing raises the questions about the cyberspace's information security. Cyberspace is vulnerable to threats and intrusion. Threats in cyberspace move at the speed of light targeting citizens, businesses and governments. It is obvious that defense against intelligent cyber weapons can be achieved only by intelligent software. Due to the high speed of cyber activity and large volume of data used, defense against threats of cyber space cannot be handled by any physical device or by human intervention alone. It needs considerable automation to detect threats and to make intelligent real-time decisions. It is difficult to develop software with conventional algorithms to effectively protect against the dynamically evolving attacks. This is why we need innovative approaches such as applying methods of Artificial Intelligence (AI) that provide flexibility and learning capability to software which will assist humans in fighting cybercrimes. [1]

## 2. Cyber crimes

With the growth of the Internet, cyber crimes are also growing. Internet crime takes many faces and it is committed in diverse fashion. Cybercrime means that the illegal activities are committed through the use of computers and the internet. The evolution of the internet and its diversity in the world are the sources of cybercrimes. Cybercrime can basically divide into two major categories. One in those takes the network as criminal object such as intrusion, destructing the network system etc. The others are those using the network to commit crime such as fraud [2].

Although "cybercrime" has become a common phrase today, it is difficult to define it precisely. Somaiya et.al. (2014) defines "Cybercrime is a term used widely to describe criminal activity in which computers or computer networks are a tool, a target, or a place of criminal activity"[3]. Halder et al (2011) define Cybercrimes as: "Offences that are committed against individuals or groups of individuals with a criminal motive to intentionally harm the reputation of the victim or cause physical or mental harm, or loss, to the victim directly or indirectly, using modern telecommunication networks such as Internet and mobile phones [4]. According to Kandpal et al (2013)" Cybercrime includes all unauthorized access of information and break security like privacy, password, etc. with the use of internet. Cybercrimes also includes criminal activities performed by the use of computers like virus attacks, financial crimes, sale of illegal articles, pornography, online gambling, e-mail spamming, cyber phishing, cyber stalking, unauthorized access to computer system, theft of information contained in the electronic form, e-mail bombing, physically damaging the computer system, etc." [5].

The statistics that have been obtained and reported about demonstrate the seriousness of Internet crimes in the world. "Phishing" emails alone produce one billion dollars for their perpetrators. In a FBI survey in early 2004, 90 percent of the 500 companies surveyed reported a security breach and 80 percent of those suffered a financial loss. A national statistic in 2003 stated that four billion dollars in credit card fraud are lost each year. Only two percent of credit card transactions take place over the Internet but fifty percent of the four billion, mentioned before, are from the transaction online. All these finding are just an illustration of the misuse of the Internet and a reason why Internet crime has to be slowed down [6].

## 3. Artificial Intelligence

AI (also called machine intelligence in the beginning) emerged as a research discipline at the Summer Research Project of Dartmouth College in July 1956. John McCarthy, who coined the term defines it as "the science and engineering of making intelligent machines" [7]. Universally accepted definition of artificial intelligence is that "Artificial

Intelligence is the study of how to make computers do things which, at the moment people do better". The central problems (or goals) of AI research include reasoning, knowledge, planning, learning, natural language processing (communication), perception and the ability to move and manipulate objects. An AI system must be capable of doing three things.

  i. Store knowledge
 ii. Apply the stored knowledge to solve problems
iii. Acquire new knowledge through experience

AI has three key components –Representation, Reasoning, and Learning [8].

The general problem of simulating intelligence has been simplified to specific sub-problems which have certain characteristics or capabilities that an intelligent system should exhibit. The following characteristics have received the most attention [9, 10, 11]:
a) Deduction, reasoning, problem solving
b) Knowledge representation
c) Planning
d) Machine learning
e) Natural Language Processing
f) Motion and Manipulation
g) Perception
h) Social Intelligence
i) Creativity
j) General Intelligence

Typical AI methods mainly focus on individual human behavior, knowledge representation, inference procedures. On the other hand, Distributed Artificial Intelligence (DAI) mainly focuses on social behavior. DAI systems can be defined as cooperative systems where a set of agents act together to solve a given problem. These agents are often heterogeneous. According to Jacques Ferber (1999), "An agent can be a physical or virtual entity that can act, perceive its environment (in a partial way) and communicate with others, is autonomous and has skills to achieve its goals and tendencies."[12]. Agents are distinct entities with standard boundaries and interfaces designed for problem solving. Whereas Multi-Agent system is a network of agents which are loosely coupled working as a single entity like society for problem solving that an individual agent cannot solve.

The main applications of multi-agent systems are [12]
- Problem Solving
- Multi-Agent Simulation
- Construction of Synthetic Worlds
- Collective Robotics
- Kenetic Program Design

Computational Intelligence (CI) is a branch of Artificial Intelligence which is mainly focused on heuristic algorithms such as fuzzy systems, neural networks and evolutionary computation. The term 'Soft Computing' is mutually interchangeable with Computational Intelligence. More recently, emerging areas such as artificial immune systems, swarm intelligence, chaotic systems, etc. have been added to the range of Computational Intelligence techniques [13]. The nature - inspired techniques such as neural networks, fuzzy logic, evolutionary computation, swarm intelligence, machine learning, and artificial immune system provide flexible decision making mechanism for problems like cyber security issues.

Genetic algorithms are another example of AI technique. They provide robust, adaptive and optimal solutions even for complex computing problems. They can be used for generating rules for classification security attacks and making specific rules for different security attack in intrusion detection systems (IDS) [14,15].

## 4. Intrusion Detection and Prevention System

Intrusion Detection System (IDS) can offer protection from external users and internal attackers, where traffic doesn't go past the firewall at all. The firewall defend an organization from malicious attacks from the Internet and the IDS if someone tries to break in through the firewall or manages to break in the firewall security then tries to have access on any system in the trusted side. It alerts the system administrator in case there is a breach in security. An IDS is like a smoke detector, that raise an alarm if specific things occur.

An Intrusion Detection System (IDS) is a device or software that monitors network or system activities for malicious activities or policy violations and produces reports to a management station. IDS can be Network-based Intrusion Detection Systems (NIDS) and Host-based Intrusion Detection Systems (HIDS) [16].

IDS performs a variety of functions [17]:
- Monitoring users and system activity
- Auditing system configuration for vulnerabilities and misconfigurations
- Assessing the integrity of critical system and data files
- Recognizing known attack patterns in system activity
- Identifying abnormal activity through statistical analysis
- Managing audit trials and highlighting user violation of policy or normal activity
- Installing and operating traps to record information about intruders
- Correcting system configuration errors

An **intrusion detection and prevention system (IDPS)** (See Fig. 1) is a software or hardware device placed inside the network, which can detect possible intrusions and also attempt to prevent them [1].
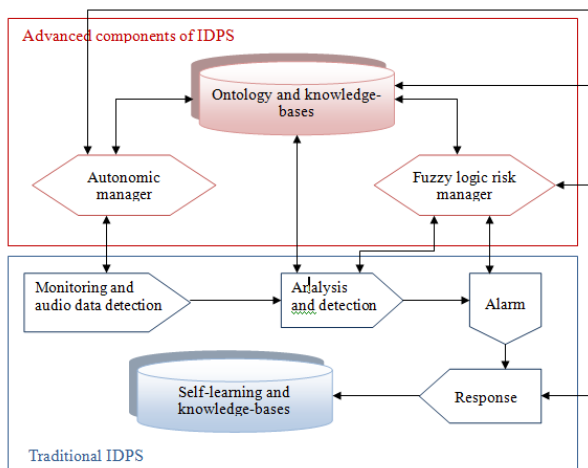
**Figure 1:** IDPS based on AI [1]

Artificial Neural Networks (ANNs) can enhance the performance of Intrusion Detection Systems (IDS) when compared with traditional methods [17]. Artificial neural networks are a stepping stone in the search for artificial intelligence. ANNs is an information processing system which is inspired by biological nervous system. ANN has tools through which we can develop AI [8].

# 5. Applications of AI Techniques in Defending Cyber Crimes

Available academic resources show that AI techniques have numerous applications in cybercrime detection and prevention. For instance, in using neural networks it is possible to develop highly efficient intrusion detection and prevention system. Proposal for using artificial neural networks in the detection of Denial of Service (DoS) attack, computer worm, spam, zombie, and in malware classification and forensic investigation also exists [18]. New generation antivirus systems are using AI techniques such as Data mining, neural networks, and heuristics methods to improve their efficiency [19]. Distributed wireless Intrusion Detection System (IDS) sometimes uses intelligent agents combined with mobile agents [20]. IDS based on mobile agents provide security for the network using mobile agent mechanisms to add mobility features for monitoring suspicious cyber activity [21].

## 5.1 Application of Artificial neural networks against cyber crimes

Artificial Neural Network is a massively parallel distributed processor made up of simple processing units, which has a natural capability for storing experimental knowledge and making it available for use [8].

Chen (2008) depicted NeuroNet – a neural network system that is proficient in monitoring the traffic, spot the traffic anomalies, and it triggers countermeasures for it. The experiment results in NS-2 showed that NeuroNet is effective against one type of hidden attack called low-rate TCP-targeted distributed DoS attacks, which is also known as shrew attacks [22] .

Iftikhar et al (2009) designed a system based on ANN to detect probing attacks. It adopted a supervised neural network phenomenon to inspect the feasibility of an approach to probing attacks that are the basis of others attacks in computer network systems. The developed system is applied to different probing attacks and while comparing its performance to other neural networks' approaches and the results indicate approach based on Multiple Layered Perceptron (MLP) architecture is more precise and accurate and it shows optimum results as compared to other methods [23].

Linda et.al (2009) presented a novel IDS-NNM – Intrusion Detection System using Neural Network based Modeling which uses a specific combination of two neural network learning algorithms namely Error-Back Propagation and Levenberg -Marquardt for behavior modeling. Experimental results showing IDS-NNM algorithm is capable of capturing all intrusion attempts presented in the network communication without generating any false alerts [24].

Barika (2009) suggests Artificial Neural Network architecture for decision making within intrusion detection systems with the goal of increased efficiency [25].

Iftikhar et al (2010) presents an evaluation of different neural network systems namely Self-Organizing Map (SOM), Adaptive Resonance Theory (ART), Online Back Propagation (OBPROP), Resilient Back Propagation (RPROP) and Support Vector Machine (SVM) towards intrusion detection mechanisms using the Multi-Criteria Decision Making (MCDM) technique. The results show that in terms of performance, supervised NNs are better, while regarding training overhead and aptitude towards handling varied and coordinated intrusion unsupervised NNs are better. From this the conclusion is that Hybrid approach of NNs is the optimal solution in the area of intrusion detection [26].

Brij (2011) ANN is employed to estimate number of zombies involved in a flooding DDoS attack which is helpful to suppress the effect of attack [27].

Wu (2009) presented a hybrid method for spam filtering which uses rule-based processing and back-propagation neural networks. Since the spamming behaviors may frequently change, this method has proven to be much more robust compared to other spam detection approaches that consider keywords [28].

Kufandirimbwa and Gotora (2012) presented a technique to spam filtering using Artificial Neural Networks, and the perception learning method which produces favourable detection rates due to the incorporation of a continuous learning feature as compared to other spam detection methods based on content and other characteristics of the message [29].

Venkatesh et al (2012) presented a Multi-Layer Feed Forward Neural Network training model using Bold Driver Back-propagation learning algorithm for HTTP Botnet

detection which has a good identification accuracy with less false positives [30].

Devikrishna et al (2013) presented A Multi Layer Perception (MLP) for intrusion detection and used Knowledge discovery in Database (KDD) for classification of attacks [31].

Zhai (2014) proposed a multi-agent distributed IDS (DIDS) model based on BP neural network for intrusion detection with the advantages of reducing the amount mobile process of data, load balancing, detecting analysis neatly, better error-tolerating, and detecting distributed intrusion effectively [32].

## 5.2 Application of Intelligent agents against cyber crimes

Intelligent agents are autonomous computer-generated forces with the capability to communicate with each other to share data and they can cooperate with each other in order to plan and implement appropriate responses in case of unexpected events. The intelligent agents' characteristics like mobility, adaptability in the environments they are deployed in, and their collaborative nature, makes them suitable for combating cyber attacks.

Rowe (2003) developed a tool to systematically counter plan the ways to prevent particular cyber attack plans using multi-agent planning and some novel inference methods [33].

Helano (2006) introduced a system implemented in Prolog which is a synthesis based on a multi-agent systems (MAS) approach with a practical case used to fight cyber intrusions and with the ability to verify the properties of cybercrimes [34].

Mueen Uddin et.al (2010) proposed a new model called Dynamic Multi-Layer Signature based IDS using Mobile Agents, which can detect forthcoming threats with very high success rate by dynamically and automatically creating and using small and efficient multiple databases, with a mechanism to update these small signature databases at regular intervals using Mobile Agents [35] .

Mayank et al (2011) simulated dynamic mobile agent model using Colored Petri Nets (CPNs) which enables the owner of the agent to detect the malicious host. The simulation result clearly proves that owner can detect the malicious hosts and thus prevent Denial of service attack to occur in real world [36].

Akyazi et al (2012) proposed a distributed intrusion detection system to detect Distributed Denial of Service attacks in a special dataset. This method is tested in a simulated-real time environment, in which the mobile agents are synchronized with the timestamp given in the dataset [37].

Onashoga et al (2013) proposed a Multi agent-based architecture for Intrusion Detection System (IDS) to overcome the shortcoming of current Mobile Agent-based

Intrusion Detection System, with three major phases namely: Data gathering, Detection and the Response phase [38].

M. Rajesh Kanna et al (2013) designed a wireless distributed Wireless Intrusion Detection System (WIDS) based on Intelligent agents which consist four major components: Intrusion detection module, Alert, Mobile agent platform, Test suit [20].

## 5.3 Application of artificial immune system against cyber crimes

Artificial Immune Systems (AIS) are a class of computationally intelligent systems which imitate the biological immune systems. Since the artificial immune system has techniques to solve complex computations, AIS plays an important role in the cyber security research.

Zhang et al (2011) proposed a hierarchical Distributed Intrusion Detection SGDIDS namely SGDIDS System that is applicable to identification of malicious network traffic and improving system security for improving cyber security of the Smart Grid with an intelligent module. This system uses AIS to detect and classify malicious data and possible cyber attacks [39].

Amit Kumar et al (2012) proposed a new general HTTP Botnet detection framework for real time network using Artificial Immune System (AIS) with no need for prior knowledge of Botnets [40].

Ismaila (2012) proposed a spam detection model based on negative selection algorithm that generates a new self (system) that randomly creates antibody against spam, by distinguishing self from non-self. The experimental result guarantees that the proposed model is able to establish a better true positive on an unknown spam [41].

Smera et al (2014) studied and compared two efficient spam filters namely Bayesian filters and Artificial Immunity filters and suggested Bayesian classifier has as an effective method to construct anti-spam filters [42].

Ibor et al (2015) proposed a highly efficient hybrid technique which is achieved using the combined features of three algorithms namely J48, Boyer Moore and K-NN for Malicious Network Traffic based on Active Response [43].

## 5.4 Application of genetic algorithm and fuzzy against cyber crimes

Liu et al (2010) to detect computer virus, the clustering method combining genetic algorithm and ant colony algorithm is adopted. From experimental results, it is clear that this method exhibits strong adaptability, shows better intelligence, and higher degree of automation in detecting virus [44].

Linda et al (2011) proposed a novel fuzzy based learning

algorithm for anomaly based network security cyber sensor together with its hardware implementation. The anomaly detection algorithm was specifically designed to allow for both fast learning and fast classification of attacks [45].

Hoque et al (2012) presented an Intrusion Detection System (IDS), by applying Genetic Algorithm (GA) to efficiently detect various types of network intrusions using the standard KDD99 benchmark dataset [46].

Ojugo et al (2012) presented a genetic algorithm based approach with its driver implementation. It employs a set of classification rule derived from network audit data [47].

Jitendra (2013) presented a genetic algorithm to detect email spam and the proposed idea is tested on 2248 mails and the overall efficiency is nearly 82% [48].

Jongsuebsuk et al (2013) depicted a network IDS based on a fuzzy genetic algorithm. Fuzzy rules are used to classify network attack data, whereas genetic algorithm optimizes the solution. The evaluation results showed that the proposed IDS can detect network attacks in real-time and within 2-3 seconds upon the arrival of data with the detection rate of over 97.5% [49].

Roshna et al (2013) presented a technique named as botnet detection using Adaptive Neuro Fuzzy Inference System (ANFIS) based on Anfis algorithm [50].

## AI flexible features for IDPSs

AI techniques have numerous traits that make it suitable for the construction of the intrusion detection and prevention system (see Table 1)

**Table 1:** AI features for IDPS

| Technology | Features |
|---|---|
| Artificial NeuralNetworks | i.Learning by example. ii. Resilience to noise and incomplete data. ii. Intuitiveness since it mimic biological neuron. |
| Intelligent Agents | i. Mobility. ii. Adaptability. ii. Collaboration. |
| Artificial Immune Systems | i. Self-adaptability. ii. self-organizing. ii. Dynamic nature. |
| Genetic Algorithms and fuzzy | i. Optimization. ii. Robustness. iii. Flexible. |

## Limitations of Existing Anomaly Detection and Prevention System

Today IDPS have become extremely valuable in enhancing the security of the networks and end hosts; they however have numerous key drawbacks [51]. They are:

- Encryption: Once the data packets are encrypted, the existing detection mechanisms may become completely futile in identifying the intrusions.
- Evasion of signatures: polymorphic worms which can automatically change their propagation characteristics thereby changing their signatures. Such worms also constitute a critical threat to the current detection system.
- False Positives: A false positive is an incident when a IDS falsely raises a security threat alarm for harmless traffic.
- Legal regulations: intrusion detection systems need to conform to legal regulations
- Attack to IDPS: may be disabled by attackers if they can learn how the system works.

## Conclusion

As we are living in an online world, most of our everyday communications and commercial activities now take place via the Internet. However, it also caused issues that are difficult to manage such as the emergence of cyber crimes. Available academic resources show that AI techniques already have numerous applications in combating cyber crimes. This paper has briefly presented possibilities of AI techniques so far in cyber field for combating cyber crimes and their current limitations.

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