TOPICS: GENERAL OVERVIEW OF ARTIFICIAL NEURAL NETWORKS AND ITS APPLICATIONS

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RESEARCH PAPER

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ABSTRACT

Artificial Intelligence (AI) is a field of science that combines computer science, philosophy, and physiology, to study the human intelligence, ideology and apply them to the machines, so that, it would be capable of having the artificial intelligence that humans are naturally intuited. Artificial Neural Networks is an essential contributor to AI that helps a system to have an artificially created intelligence with a constant learning mechanism, through various methods to have an attribute that is close to human beings. With the constant learning and reducing the error by the ANNs, they would perform their function just like a human brain with neurons. ANNs have been used in almost every field, and its application is very important from the perspective of it making people's life easier, as well as, helping the field of AI to reach the future where we would be able to create systems that are as intelligent as humans. All the technological advancement that we have today and would eventually evolve tomorrow, are the results of the research and support for AI to actually create a system that has a simulated intelligence and learning, close to human beings.

INTRODUCTION

The computer system that we use daily basically needs an *input* from the user, in the forms of data and information, which is *processed* using the stored programming concepts of the desired problem, and then, it gives the *output* in the forms of output devices as monitors. These system don't urge to have any sense of a human intelligence, even though, human intelligence is a complex topics for many scientist even today because it has unlimited scope in understanding how it actually works. Human brain or intelligence has properties that are very powerful, and, one of the most important properties is the ability to learn and respond to different situations very

differently. Artificial Neural Network (ANN) is a computing system that can learn on its own and have an artificial intelligence that is inbuilt by constant learning process, reducing the error in the desired output of the system.

HISTORY OF ANNs

Human brain is very interesting area of study which has been conducted since thousands of years ago. With today's modern day electronics, scientists are trying to create a system that functions like a brain with the features as learning, thinking etc. In 1954 the doctorate thesis of Marvin Minsky, "Theory of Neural-Analog Reinforcement Systems and its Application to the Brain-Model Problem" represented one of the best researches individually to add the contribution in the field of ANNs. In 1957, Rosenblatt's Perceptron where data must be linearly separable, couldn't solve the X-OR logic, and, in 1969, Minsky and Papert's book "Perceptron" clarified the weaknesses of the Perceptron (Clark, Will). In 1959, Hoff and Widrow of *Stanford University* developed the Madaline (Multiple Adaptive Linear Elements) and Adaline (Adaptive Linear Elements) that is still used as *filters* on the phone lines to eliminate echoes (Clark, Will). These were the first artificial neural networks that could actually be applied to the real problems. The fear of machine taking over the human and their jobs, created large scale critique of AI as well as ANNs, decreasing the funding for research projects which was started again by United States in the fear that we would be left behind in terms of research and technology with the Japanese conference that announced their research in ANNs (Adaptive Linear Elements). In 1986, the developments of the *back-propagation algorithm* to train multi-layer perceptrons had emerged (Clark, Will). The history of ANNs shows that it actually works, and, today it is one of the dynamic fields of studies in the computer science that is researching for the innovations.

Electronics companies are also working on three types of neuro-chips as digital, analog and optical, which give the promising aspects towards the future of ANNs.

ANNs AND ITS RESEARCH

Haykin in 1994 defined ANN as, "A Neural Network is a computer program designed to model the human brain and its ability to learn tasks" (Clark, Will). ANNs is trained to recognize and generalize the relationship between a set of inputs as well as outputs, which is not a rule based computer intelligence and instead, a learning system from set of given examples (Clark, Will). Basically, the ANN system consists of three layers – *input layer*, *hidden layer* and *output* layer. It takes much iteration of learning cycles for the system to actually learn to give the desired output. The hidden layer which is basically the Artificial Neural Networks, is similar to a function as, $f(x) = y$, where x is the input and y is the desired output (Roy, Asim). A network can have many layers of neurons, and the outputs of one layer of neurons can be the input of the next layers of the neurons, and, the complexity of the networks of neurons are increased more and more to get the desired output that has very negligible amount of error (Roy, Asim). The training of a network is done by adjusting the connection weights as a means of learning to minimize the error cycles. ANNs goes through many cycles of learning, by adjusting weights to the neural networks, so that, it would minimize the error that is produced as the output of the Neural Networks, until, it gives us our desired output (Roy, Asim). Doing this, we would create a system that is not hardcoded to get our desired output; rather the system is trained to get our desired output. We may think that we could have simply hardcoded the desired output, but in long run, and as the problem gets complicated, it would be really nice and efficient, if we have a system that would learn by itself with many iterations of error corrections. This would be an intelligent system and, it could perform many parallel complex computations and logic, that a

human brain is capable of, but, the positives is that - it can perform faster and develop human civilization to explore the infinity of the space. We could use these intelligent systems to go to Mars, explore our Galaxy, as well as, the infinity of the Universe.

Feed forward, back-propagation, delta bar delta, extended delta bar delta, directed random search, higher-order Neural Network or functional-link network and self-organizing map into back-propagation are some of the networks for *prediction* of the ANNs (Clark, Will). ANNs can be linked to other systems as fuzzy logic, kinetic algorithms as well as expert systems because they learn rather than they are programmed, and even though, they are susceptible to small margin of errors, they could be very powerful to change our civilization and mankind for the greater benefit to technology and advancement (Clark, Will).

Learning process by ANNs is fascinating and interesting. They don't know *anything* and must be *trained* that starts out with randomized *weights* for all their neurons (Kay, Alexx). The training can be broadly categorized into methods that include - a self-organizing ANNs and a back-propagation ANN (Kay, Alexx). A self-organizing ANNs is exposed to large amounts of data, whereas, a back-propagation ANN is trained by human and they measure the correctness of the neural weights to the desired output which is reinforced, if the output is correct, and, if the output is incorrect then the weights responsible are diminished (Kay, Alexx). This process continues until the output is correct which directly or indirectly means the system has *learned* to perform certain operations without hardcoding the solution.

Recently, two of the giants of the technology and innovation, *Google* and *Microsoft*, jointly spoke to the audience about Artificial Intelligence and its optimism about the future of the machine intelligence in Palo Alto, California (Simonite, Tom). Peter Norvig who is Google's

director of research, pointed out that we don't need to tell a learning system everything, and, instead, we can pursue the system to have reinforcement learning which gives rewards or punishment according the task performed (Simonite, Tom). He also pointed out that *Stanford* and Berkeley's groups of research teams demonstrated the system's apprentice learning that would learn by example, which created helicopters that learned to fly looking at the human expert (Simonite, Tom). Therefore, the vastness and scope of Artificial Intelligence is very important and promising for human civilization.

In 2011, researchers at the *California Institute of Technology*, Caltech, have taken a major step by creating systems of DNA molecules whose interactions simulate the behavior of Artificial Neural Networks in the test tubes, and, they are the first to have made an ANNs out of DNA that created a circuit of interacting molecules to recall memories just like a brain of a human (Qian, Lulu). This is a new direction in the future of ANNs, and, it is very exciting to see how far it goes, and, what benefits we get out of it. The research consisted four artificial neurons that was made out of 112 distinct DNA strands that plays a mind reading game where it tried to identify the name one of the four scientist (Qian, Lulu). Erik Winfree, co-author and the professor of computer science, computation and neural systems, and bioengineering says that the model used in the research is an oversimplification of the real neurons, but, it is nevertheless a good one because it has been a productive model for exploring the simple computational element's that showed the brain like behavior as associative recall and pattern completion (Qian, Lulu). The experiment was limited and a network of just 40 of the DNA-based neurons was used in contrast to 100 billion of neurons in the human brain (Qian, Lulu). The game could only be played once because the molecules were unable to detach and pair up with a different strand of DNS, after completing their tasks that took 8 hours to identify each mystery scientist (Qian,

Lulu). Nevertheless, this shows completely *different approach* towards Artificial Neural Networks and with the future research in this field, it could yield some interesting and very important application by creating ANNs out of DNA.

APPLICATIONS

Artificial Neural Networks have contributed greatly towards the study and practice of Artificial Intelligence. With the history of research and development in the ANNs, the *application* of ANNs has been conducted in many fields by effectively solving the problem which could have not been possible if ANNs were not applied to solve it. Some of the fields where they are applied are - detecting DOS attacks, real time flood forecasting, speech recognition, environmental catalysis, fossil hunt, speech synthesizer, pattern recognition, Medical science, hybrid-intelligent framework to secure e-government web applications, food science etc.

Denial of Service Attack (DOS Attack) can cause very massive loss in computer and network systems which may result in the compromise of the company data as well as the data of the customers, creating a loss of thousands of dollars, if not, millions. Supervised neural networks using multiple layered perceptron architecture and resilient back propagation for its testing and training, the attack could be handled more efficiently (Ahmad, Iftikhar).

Nina Balcan, the computer scientist from the *Georgia Institute of Technology* has been awarded with a Microsoft Research Faculty Fellowship of $200,000 for developing machine learning methods that could be used to develop programs that detect the *spams* in our email (Zeitler, Nicolas) Her research could also be used broadly to solve the data mining problems, phishing websites, and spoofed emails. The program learns as users provide information for the

emails that are spams and the one that are not, meaning – it uses the *supervised learning* methods. She believes in a better method for spam protection with the use of *active learning* by the programs, because it would substantially decrease the user involvement in teaching the system to learn the differentiation between a spam email and the one which is legitimate (Zeitler, Nicolas). But, the drawbacks of active learning is that if the legitimate email would be marked spam, then the system would never recover and she is looking for robust methods to even more efficiently distinguish spammed email (Zeitler, Nicolas). Her future research would try to find out better solution by not only focusing on machine learning but, rather to also connect with game theory, economics, and optimization (Zeitler, Nicolas). She is committed towards the innovation, and she said that she would use continually have a research by collaborating with other scientists as well as hire postdoc researchers and graduate students for her research group (Zeitler, Nicolas).

E-Government Web Application certainly needs to have an extra level of security without any doubt, and, web application firewalls are mandatory for that application to protect it from getting compromised. HiWAF is a web application firewall that utilizes ANNs as well as *fuzzy logic* which is a hybrid intelligent web application firewall that works in three modes as positive, negative, and, session based security modes (Moosa, Asaad). On the application layer of the OSI stack, the HiWAF should be intelligent enough to distinguish whether the incoming data can be classified as safe or has a potential threat that is determined by the three modes of the HiWAF (Moosa, Asaad). *Positive logic filtering* would allow trusted requests that are already defined to be making interactions with the web application (Moosa, Asaad). *Negative logic filtering* has signatures of the known attacks and it checks those definitions and rejects the requests to access the web application (Moosa, Asaad). *Session based filtering* utilizes the session created by the

trusted users during user session and ensures the filtering of the authorized as well as authenticated users to be able to access the applications (Moosa, Asaad). BinarySEC WAF uses Artificial Intelligence and in particular, ANNs to achieve two tasks to set the normal traffic and to detect abnormal traffic, blocking and alerting which is the first web application that used ANNs for web application security (Moosa, Asaad). It has some limitations and therefore, it is rather recommended to use HiWAF that would utilize the ANNs as well as the *fuzzy logic*. The architecture proposed by Moosa consists of 5 stages of work of which the first step starts from the development of the application, in which the application designer after finishing the design, they should be tested using Web Application Scanner (WAP), until there is not a single security failure (Moosa, Asaad). In the second stage, the final version of the web application would be locally hosted on the system's web servers, application servers and, database servers (Moosa, Asaad). The third stage is the training stage for the ANNs and fuzzy logic to identify both the positive as well as negative logic based filtering followed by the training for the final hybrid intelligent system (Moosa, Asaad). The fourth stage involves building and preparing session management unit as well as session based filtering unit (Moosa, Asaad). In the fifth stage, SSL management unit and types of encryption or decryption setting would be considered (Moosa, Asaad). After everything thing is done and the client request is started to be accepted, the *hybrid system* will check the request and works in three phases – fuzzy logic, neural networks and the fuzzy-neuro unit that is followed by the intelligent AND function (Moosa, Asaad). The AND function would decide on checking if the request is legitimate or not and would accept or deny accordingly creating a session for secured interaction between the user and the web application (Moosa, Asaad). All of the process discussed would run very quickly as compared to the traditional filtering approaches simply because of the fact that they are using neural networks and

fuzzy logic (Moosa, Asaad). Therefore, the use of ANNs, fuzzy logic and fuzzy-neuro for securing the e-Government web application could be very efficient from the security standpoint and much of the research could be performed on it to even more efficiently secure those web applications.

Flood forecasting is very essential in preparing for the flood disaster. Many approaches are developed to carry out its forecasts which are basically stochastic in nature and involve statistical understanding (Ayalew, Lulseged). In Ethiopia, ANNs with back propagation algorithms had been used in Omo River for flood forecasting and, the study suggested that the ANN technique demonstrated the potential effectiveness of its use with efficiency and accuracy (Ayalew, Lulseged).

Speech Recognition is very important in the future of technological advancement because it would contribute massively towards creating a system that can communicate with humans more efficiently, making our life easier. ANNs have been contributing to improve speech recognition performance approximately since 1980s by using ANN-Hidden Markov Model (ANN-HMM) which was outperformed by context-dependent Gaussian mixture model HMMs (CD-GMM-HMMs) (Chang, Janie). In June 2010, Yu and the members of the Speech group at Microsoft Research Redmond with the intern George Dahl from the University of Toronto, began investigating how more complex deep neural networks (DNNs) could be used to improve large vocabulary speech recognition (Chang, Janie). Their study showed that the modeling senones directly using DNNs outperformed the state-of-the-art conventional CD-GMM-HMM large-vocabulary speech recognition systems and the relative error were reduced more than 16 percent (Chang, Janie). This research by Microsoft is still ongoing to further get more insights and practicability for actually being able to use it in our daily life. With this innovation, we can

imagine speech-to-speech applications as a reality as well as it would deliver high accuracy for large vocabulary speech recognition tasks, making our life easier (Chang, Janie). It can change the very way of life of humans that we know of today.

The use of ANNs in designing *speech synthesizers* for English language is much easier as compared to a Persian language because the design is largely dependent on the structure of the language which the English language seems to have more simplicity than a Persian (Hendessi, F). With the complexity in the process of extracting phonetic spelling in Persian, the accuracy of using ANNs would result poor efficiency (Hendessi, F). Rather, the composite method with three stages is used as word processing, sentence processing, and speech generation (Hendessi, F). In word processing, the extraction of phonetic spelling is done using a two layer perceptron neural network followed by back propagation learning algorithm for training (Hendessi, F). Since the pronunciation of a word may differ slightly depending on the sentence with the vowel of the last letter in each word, it requires some grammatical processing that is carried out in sentence processing (Hendessi, F). Speech generation considers a system that would accept the phonetic spelling and gives the speech as an output (Hendessi, F). The study showed that using ANNs to design speech synthesizers for the Persian language seems to have a satisfactory result than the dictionary based phonetic spelling extracting systems (Hendessi, F).

Apple and Google build smartphone controlled and Wi-Fi enabled thermostat that costs $249 and it is smart and has the ability to be learn (Layer 8: After the IPod, Ex-Apple Engineers Built World's Coolest Thermostat). Fadell says, “The thermostat learns your daily routine via a machine learning program and can adjust itself based on your preferred temperatures and schedule”. When we come home it can sense us and pushes up the A/C or heat or it can give us the tips and feedback on the energy use (Layer 8: After the IPod, Ex-Apple Engineers Built

World's Coolest Thermostat). It learns what sort of temperature we like and programs itself and smartly turns it down when we are not at home (Layer 8: After the IPod, Ex-Apple Engineers Built World's Coolest Thermostat). The device would be available in the market by the end of the year 2011and it is an excellent application of ANNs that would eventually make our life easier as well as help us in conservation of energy and money (Layer 8: After the IPod, Ex-Apple Engineers Built World's Coolest Thermostat).

ANNs can be used in *environmental catalysis* as in many crucial problems, such as, catalyst formulation, optimal conditions for catalytic systems exploitation and many others to be efficiently solved (Diaconescu, Rodica). They are also used widely for *medical applications* as cardiology. They have been applied in diagnosis, electronic signal analysis, medical image analysis and radiology, as well as, it has been used for modeling in medicine and clinical research (JL, Patel).Increasing use of ANNs in pharmacoepidemiology and medical data mining illustrates the importance of ANNs in medical field. ANNs are also very useful tools for food safety and quality analysis which includes modeling microbial growth and from this predicting food safety, interpreting spectroscopic data, and predicting physical, chemical, and functional properties of food products during processing and distribution (Y, Huang). Since, the ANNs in the *food science* are still in the process of a development stage, in future, we might see many advancement and its applications for solving complex problems.

Cardiac infections such as, Endocarditis – "an infection involving the valves and sometimes chambers of the heart" can be very painful as well as the mortality rate can be as high as one in five (Artificial Intelligence Helps Diagnose Cardiac Infections). But, the software program of ANNs that mimics the cognitive function of the patient's brain and with many training sessions, it excluded endocarditis in half of the cases which eliminated the invasive

procedure with the patients (Artificial Intelligence Helps Diagnose Cardiac Infections). The study from 1991 to 2003 suggest that the ANNs were successful to diagnosis the endocarditis successfully that yielded the confidence level of greater than 99 percent (Artificial Intelligence Helps Diagnose Cardiac Infections). Therefore, ANNs help successfully diagnose cardiac infections.

Fossil-hunting paleontologist are using computer learning systems as ANNs to spot prospective fossil sites data from satellite as Landsat7, by teaching it what to look for (Hecht, Jeff). The study of pattern recognition and learning by Landsat7 is done by six bands of visible and infrared light recorded (Darleen Hartley). The software gave results that the fossil sites were in sandstones, but, not all sandstones have fossils (Hecht, Jeff). They added two more criteria to better come up with the fossil rich surfaces which would help paleontologist to better search for the fossil. With the testing of this Artificial Neural Network Software over the sites that were already identified as the sites that had fossils, the ANNs identified 79 percent of them and it correctly tagged 99 percent that contained fossils (Darleen Hartley). In July of 2012, anemone and his team is planning to have an on-site excursion into the Wyoming areas which were tagged by the ANN Software for the likelihood of having the hidden fossils which integrates an interesting fact of a combination of AI and human sweat to locate fossils from the earth (Darleen Hartley).

Roberts as Topio uses ANNs for their functionality such as playing ping-pong with humans. Topoi's ANNs would enable it to detect the ball's path, served balls, returned balls, and scored with the help of its motorized joints that provided backhand and forehand capabilities with many arm movements (Owano, Nancy). This Robert was developed by Zhejiang University and the director of the university's Robotics Laboratory, Xiong Rong said that it took four years

to develop it because the game like ping-pong requires fast responses as well as reflexes (Owano, Nancy). The Robert used eye-mounted cameras that can capture 120 images per second and the reports suggests that the landing position of the ball is very accurate with the margin of error, 2.5 cm (Owano, Nancy). Topio is an example of current day advancement and application of ANNs in the field of biotechnology, information technology and automation which certainly shows us the possibility of the use of ANNs and Robotic technology (Owano, Nancy).

With the development of IV & V Neural Networks called IVVNN and the institute of Scientific Research (ISR) with the help of West Virginia University, initiated a further study and research on these sets of ANNs to make sure that they meet the requirements of IEEE Std. 1012-1998 (Benson, Markland). Later they were tested by ISR on the F-15 Intelligent Flight Control System (IFCS) project so that, they would be able to test ANNs if they could improve the flight safety and as an assurance of ANNs to be used for efficiency (Benson, Markland). Therefore, IVVNN opened the way for a confirmation that ANNs are *reliable and efficient* to be used for critical systems in NASA as well as any other applications that are using ANNs which is a huge step towards its credibility in its application (Benson, Markland).

Automation in the Space programs are very important because the missions that are impossible for a human to conduct efficiently could be solved by using advanced machine intelligence and robotic technologies (Freitas, Robert A). Therefore, the research in the fields of Artificial Intelligence seems to be very important for NASA and any others involved in the exploration of the space and the life beyond the Earth. These intelligent systems could be sent to space which have human like intelligence to make decisions, learning capabilities and sending back the information that can be vital for the exploration. The exploration of moon using intelligent image processing systems around the moon could be efficient with a self-replicating

manufacturing facility that could produce thousands of meter-long robot rovers could study entire moon in just few years, even though, such exploration could take a century using more conventional methods (Freitas, Robert A). Because, Moon has lower gravity, lack of atmosphere and relative abundance of energy and raw materials than Earth, the Moon could be the better alternative for construction and launching of the future generations of interplanetary exploratory spacecraft (Freitas, Robert A). The ANNs could be used for interstellar and galactic applications, solar system applications. The concept of machines that are capable and intelligent enough to construct other machines and replicate themselves can be very beneficial which would help to compute, construct, reproduce, and inspect, repair, simulate, and observe themselves as well as other machines, contributing to the civilization of human mankind to explore the universe (Freitas, Robert A).

FUTURE OF ANNs

Since they are better suited than traditional computer architectures in which humans are naturally good, the future of ANNs seems to be very promising. Simulating human intelligence is still the realm of science fiction and it cannot be confirmed with certainty that the mankind would ever be successful on it. But, the research and innovation in this field would certainly benefit in solving smaller problems that could not have been possible with traditional computers. The integration of ANNs with fuzzy logic, pulsed neural networks or even other field of science and technology as biology, psychology, physics, chemistry etc. could yield a lot of perspectives in the process of making a system that is close to human brain and its functionality.

CONCLUSION

Artificial intelligence with the help of Artificial Neural Networks can create a system that has some degree of simulated intelligence, and it could learn by itself that can be used to efficiently solve many complex problems, such as - creating automation in the space programs, making efficient Roberts, Denial of Service Attack, detection of the spams, E-Government Web Application, Flood forecasting, Speech Recognition, speech synthesizers, learning thermostats, environmental catalysis, Cardiac infections, Fossil-hunting and endless others. The research and innovation in the fields of ANNs is incredible and further funding in it by Government or private companies like Google, Microsoft, and IBM would certainly help explore more innovations in its field. The recent research and new innovations such as, the idea of creating ANNs actually in a test tube that solved a problem is mind blowing and, an indication that ANNs integrated with other fields may have a completely different way of looking our main purpose to create a system that is close to inhibit an intelligence of a human. I'm personally intrigued by Artificial Neural Networks and Artificial Intelligence, in general. This year we already saw many studies and innovations in the field of ANNs which helped us to make our life easier and better.

Works Cited:

Ahmad, Iftikhar, Azween B. Abdullah, and Abdullah S. Alghamdi. "Application of Artificial Neural Network in Detection of DOS Attacks." *ACM Digital Library*. ACM New York, NY, USA ©2009, 2009. Web. 07 Nov. 2011. <http://dl.acm.org/citation.cfm?id=1626195.1626252>.

"Artificial Intelligence Helps Diagnose Cardiac Infections." *PhysOrg.com - Science News, Technology, Physics, Nanotechnology, Space Science, Earth Science, Medicine*. Mayo Clinic, 12 Sept. 2009. Web. 07 Dec. 2011. <http://www.physorg.com/news171987074.html>.

Ayalew, Lulseged, Dietmar P. F. Möller, and Gerhard Reik. "Using Artificial Neural Networks (ANN) for Real Time Flood Forecasting, the Omo River Case in Southern Ethiopia." *ACM Digital Library*. Society for Computer Simulation International San Diego, CA, USA ©2007, 2007. Web. 07 Nov. 2011. <http://dl.acm.org/citation.cfm?id=1357910.1358125>.

Benson Markland. "NASA - IV&V Facility - IV&V News - News Archive - IV&V of Neural Networks."*NASA - Home*. 09 Jan. 2006. Web. 07 Dec. 2011. <http://www.nasa.gov/centers/ivv/news/news_ivvnn.html>.

Chang, Janie. "Speech Recognition Leaps Forward - Microsoft Research." Microsoft Research - Turning Ideas into Reality. Microsoft, 29 Aug. 2011. Web. 24 Nov. 2011. <http://research.microsoft.com/en-us/news/features/speechrecognition-082911.aspx>.

Clark, Will. "Artificial Neural Networks." Berkeley.edu. Berkeley, 10 Apr. 2006. Web. 25 Nov. 2011. <http://nature.berkeley.edu/~bingxu/UU/geocomp/Week14/Will_Artificial%20Neural%20Networks.pdf>.

Darleen Hartley. "Artificial Intelligence Joins the Fossil Hunt." Bright Side Of News, 22 Nov. 2011. Web. 7 Dec. 2011. <http://www.brightsideofnews.com/news/2011/11/22/fossils-unearthed-using-artificial-neural-network-software.aspx>.

Diaconescu, Rodica, and Emil Dumitriu. "APPLICATIONS OF ARTIFICIAL NEURAL NETWORKS IN ENVIRONMENTAL CATALYSIS." 2005. Web. 7 Nov. 2011. <http://proxy01.ccis.edu:2267/ehost/detail?sid=acf69062-1bc2-4077-a8f3-4e2285d33425%40sessionmgr13&vid=1&hid=7&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3d%3d#db=eih&AN=33362241>.

Freitas, Robert A., and William P. Gilbreath. "NASA's Advanced Automation for Space Missions." *Island One Society*. NASA Conference Publication 2255, 25 June 1999. Web. 07 Dec. 2011. <http://www.islandone.org/MMSG/aasm/>.

Hecht, Jeff. "Artificial Intelligence Joins the Fossil Hunt - Tech - 08 November 2011 - New Scientist." Science News and Science Jobs from New Scientist - New Scientist. NewScientist Tech, 08 Nov. 2011. Web. 24 Nov. 2011. <http://www.newscientist.com/article/mg21228376.000-artificial-intelligence-joins-the-fossil-hunt.html>.

Hendessi, F., A. Ghayoori, and T. A. Gulliver. "A Speech Synthesizer for Persian Text Using a Neural Network with a Smooth Ergodic HMM." *ACM Digital Library*. Mar. 2005. Web. 05 Nov. 2011. <http://dl.acm.org/citation.cfm?id=1066081>.

Jesan, John Peter. "The Neural Approach to Pattern Recognition." Ubiquity, Apr. 2004. Web. 5 Nov. 2011. <http://dl.acm.org/citation.cfm?id=985625&coll=portal&dl=ACM>.

JL, Patel, and Goyal RK. "Applications of Artificial Neural Networks in Medical Science." *Applications of Artificial Neural Networks in Medical Science.* 2007. Web. 7 Nov. 2011. <http://proxy01.ccis.edu:2267/ehost/detail?sid=c1e6b2b4-263b-4848-bc21-93fd98be407a%40sessionmgr11&vid=1&hid=7&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3d%3d#db=cmedm&AN=18690868>.

Kay, Alexx. "Artificial Neural Networks - Computerworld." *Computerworld - IT News, Features, Blogs, Tech Reviews, Career Advice*. 12 Feb. 2001. Web. 07 Nov. 2011. <http://www.computerworld.com/s/article/57545/Artificial_Neural_Networks?taxonomyId=11>.

"Layer 8: After the IPod, Ex-Apple Engineers Built World's Coolest Thermostat." *Network World*. 25 Oct. 2011. Web. 07 Dec. 2011. <http://www.networkworld.com/community/blog/after-ipod-ex-apple-engineers-built-worlds-co>.

Miikkulainen, Risto. "Evolving Neural Networks." *ACM Digital Library*. GECCO '11 Proceedings of the 13th Annual Conference Companion on Genetic and Evolutionary Computation, 2011. Web. 07 Nov. 2011. <http://dl.acm.org/citation.cfm?id=2001858.2002124>.

Moosa, Asaad, and Eanas Muhsen Alsaffar. "Proposing a Hybrid-intelligent Framework to Secure E-government Web Applications." *ACM Digital Library*. ACM New York, NY, USA ©2008, 2008. Web. 07 Nov. 2011. <http://dl.acm.org/citation.cfm?id=1509096.1509109>.

Owano, Nancy. "Ping-pong Robots Debut in China (w/ Video)." *PhysOrg.com - Science News, Technology, Physics, Nanotechnology, Space Science, Earth Science, Medicine*. Physorg.com, 15 Oct. 2011. Web. 07 Dec. 2011. <http://www.physorg.com/news/2011-10-ping-pong-robots-debut-china-video.html>.

Qian, Lulu. "Researchers Create the First Artificial Neural Network out of DNA." PhysOrg.com - Science News, Technology, Physics, Nanotechnology, Space Science, Earth Science, Medicine. Physorg.com, 20 July 2011. Web. 25 Nov. 2011. <http://www.physorg.com/news/2011-07-artificial-neural-network-dna.html>.

Roy, Asim. "Artificial Neural Networks." *ACM Digital Library*. ACM New York, NY, USA, Jan. 2000. Web. 07 Nov. 2011. <http://dl.acm.org/citation.cfm?id=846183.846192>.

Simonite, Tom. "Google and Microsoft Talk Artificial Intelligence - Technology Review." Technology Review: The Authority on the Future of Technology. MIT, 18 Nov. 2011. Web. 24 Nov. 2011. <http://www.technologyreview.com/computing/39156/>.

Y, Huang, Rasco BA, and Kangas LJ. "Applications of Artificial Neural Networks (ANNs) in Food Science." *Applications of Artificial Neural Networks (ANNs) in Food Science.* Journal Article; Research Support, Non-U.S. Gov't; Research Support, U.S. Gov't, Non-P.H.S.; Review, 2007. Web. 7 Nov. 2011. <http://proxy01.ccis.edu:2267/ehost/detail?sid=0352bc67-7e76-4f5e-9367-e0f24ade804a%40sessionmgr10&vid=1&hid=7&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3d%3d#db=cmedm&AN=17364697>.

Zeitler, Nicolas. "Researcher Teaches Computers to Detect Spam More Accurately."*Network World*. 5 Dec. 2011. Web. 07 Dec. 2011. <http://www.networkworld.com/news/2011/081011-researcher-teaches-computers-to-detect.html>.