APPLYING ARTIFICIAL INTELLIGENCE TO EMERGENCY AND DISASTER MANAGEMENT

Thomas V. Robertson

Thinking Teams[1]
thinkingteams@gmail.com

Abstract

Artificial Intelligence (AI) is concerned with computer systems that perform tasks associated with human intelligence, such as recognizing faces, understanding language, playing chess, assembling electronics, or driving a car. Artificial Neural Networks (ANNs), the earliest approach to AI, has seen a resurgence since 2010, as more powerful computers, abundant digital data, and engineering advances have made very large ANNs possible. These 'deep' ANNs can find complex patterns in large volumes of data, and use these patterns to support planning, prediction, situation assessment, and decision making throughout the four phases of the Disaster Management Cycle: Mitigation, Preparation, Response, and Recovery.

Keywords: artificial intelligence, emergency and disaster management, artificial neural network, deep learning

Introduction

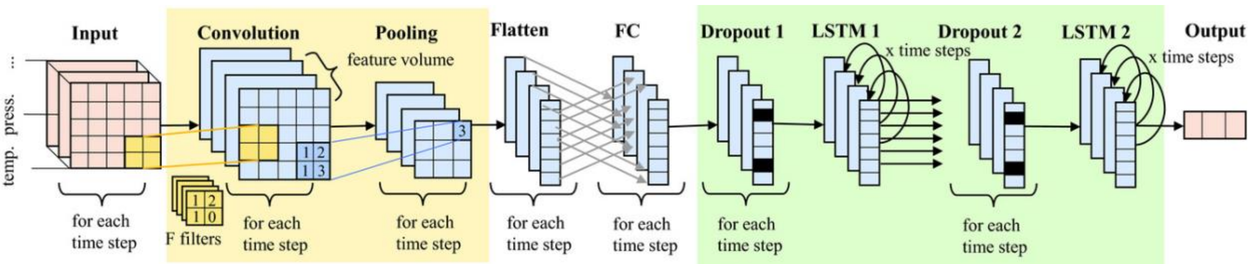
AI research and development has been going on since the 1950's (Rosenblatt, 1957). Since that time methods from various branches of mathematics and computer science have been pressed into service to develop computer-based systems that perform tasks associated with human intelligence. Examples of approaches to AI include:

- **Artificial Neural Networks (ANN)** – ANNs interconnect large networks of simple computing units. ANNs, the earliest approach to AI, was inspired by the human brain's interconnection of billions of relatively simple neurons. In the 1950's engineers discovered that ANNs could learn to do mathematical calculations by giving them enough examples and designing them to systematically adjust themselves until they get correct answers. An example of today's use of ANNs is facial recognition.
- **Symbolic Logic** – this approach to AI attempts to replicate human conscious reasoning by creating formal 'languages' that represent objects, ideas, and actions, and the relationships among them. The AI is then given rules about how to answer questions and solve problems concerning the things it 'knows'. For example, when we ask the mapping app on our smartphone to find us the best route to an address, it is using a limited form of symbolic logic that allows it to represent the world and navigate through it.
- **Expert Systems** – these AIs rely on databases of knowledge put together with the help of experts, so the AI can answer questions about a specialized field such as medicine or how to use a bank's website. A common use today of expert systems is chatbots, that can carry on a conversation with a customer and help answer their questions.
- **Mathematical statistics** – these AIs use mathematical models to describe likelihoods of particular events happening, such the stock market going up, or whether a person will be interested in a particular product. Today AIs such as these are used to make recommendations for products that are presented to you on the internet.

ANNs are the Leading Edge of AI

The earliest approach to AI, artificial neural networks (ANNs), generated much excitement when first discovered. But by the 1970s the approach was largely abandoned, because it had failed to perform as expected. A few researchers continued to champion the approach, and by around 2010 ANNs began to make impressive advances.

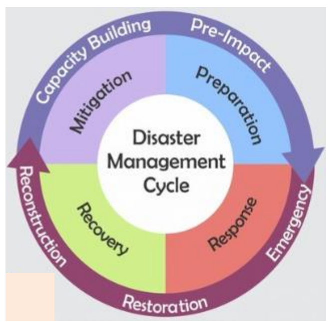
Today, modern computing power, the internet, and clever engineering have made it possible to create ANNs with millions (Howard et al., 2017) or even billions (Hannun et al., 2014) of units, and train them with millions of examples to recognize objects and people, translate languages, play complex games, control robots, and drive cars. The network below uses about 700,000 units to forecast global weather (Roesch and Günther, 2017).



These very large ANNs (sometimes called Deep Neural Networks) have performed so well that they dominate discussion of AI today. Because ANNs are on the leading edge of AI, other approaches developed through AI research, while very useful, are often considered to be more ordinary components of software applications.

So, while ANNs are not the only form of AI that will benefit Emergency and Disaster Management (EDM), the rest of this discussion will focus on ANNs, since they have led to the most recent advances in AI.

How Can ANNs Help Emergency and Disaster Management?

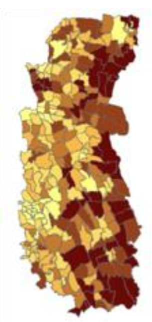


ANNs map patterns in data to outputs that represent some useful interpretation of the data, such as a likely flood zone or the amount of building damage. Below are some examples of how ANNs can be used to help detect and interpret patterns throughout the four phases of the Disaster Management Cycle: Mitigation, Preparation, Response, and Recovery.

Mitigation

Mitigation seeks to reduce the risks associated with emergencies and disasters. In some cases, emergencies can be predicted and prevented by analysing patterns in a particular situation. For example, AI is being used to predict (Man, 2019) and help prevent construction job site risks.

Natural disasters may not be preventable, but AI can recognize patterns in the environment to predict disasters and provide early warning (PreventionWeb, 2020).



Poor urban areas are especially vulnerable to disasters and poverty data is in scare supply and difficult to collect. Researchers at Oak Ridge National Laboratory in the US have developed an AI-based technique (Molinario and Deparday, 2019) to identify poor, informal settlements from high-resolution satellite imagery. Their approach used a variety of spatial, structural, and contextual features to classify areas as formal, informal, and non-settlement classes. The method was tested in Caracas, Kabul, Kandahar, and La Paz, and demonstrated that good accuracy could be obtained using the same features in these diverse areas.

Preparation

Disaster preparation ensures responders and the public are as ready as possible to deal with disasters in a way that minimizes their impact. A primary responsibility of emergency managers is to develop good plans to execute when disaster strikes. Such plans must deal with patterns of natural and social phenomena, and AI can help analyse these patterns and guide effective planning.

For example, Google has been partnering with India's Central Water Commission to develop AI-enabled flood forecasting and early warning (Vincent, 2018). Google uses a variety of elements such as historical events, river level readings, terrain and elevation, to run hundreds of thousands of simulations for each location to create river flood forecasting models that can more accurately predict where and when a flood might occur, and also how severe it will be.

Response

Emergency response must provide aid where it is needed. Knowing where and what sort of aid is needed is a challenge, especially in large-scale disasters. Our modern world is flooded with situational information from social media, surveillance cameras (fixed, drones, satellites), and internet-of-things sensors. However, it is very challenging for emergency managers to sort through and interpret this data. This is an ideal application for AI.

A system called Artificial Intelligence for Digital Response (AIDR) (Alam et al., 2018) has been developed to help analyse Twitter tweets during emergencies and disasters. The system is available as free and open software, and it is designed to be tailored to responder needs. The responder first identifies keywords and/or hashtags that are used as a preliminary filter for tweets. Next responders identify topics of interest such as "Medical Needs" or "Sheltering", and manually tag example tweets in each category. The ANN then learns to classify relevant tweets in each category, and automatically streams relevant information to responders.

Recovery

During disaster recovery a wide range of activities are undertaken to attend to casualties and survivors, restore buildings and infrastructure, and re-establish social systems and businesses. When international aid is involved, complex interactions among multiple organizations must be coordinated. Situation assessment, resource allocation, and planning can all be supported by AI's ability to recognize patterns in data.

For example, Google, in collaboration with the United Nations world Food Program Innovation Accelerator, has developed a system (Xu, 2020) for automatic damage assessment using very high-resolution satellite imagery. The system uses a form of ANN called a Convolutional Neural Network, to identify buildings and compare their condition before and after the disaster. This automated damage assessment can greatly improve the timeliness and effectiveness of recovery efforts for large-scale disasters such as the 2010 Haiti earthquake, which required assessment of over 90,000 buildings in the Port-au-Prince area alone.

Conclusion

Leading edge Artificial Intelligence using large artificial neural networks have proven to be very effective in analysing patterns in large volumes of data and mapping those patterns to information that can support the planning, prediction, situation assessment, and decision making required for Emergency and Disaster Management.

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