Some Educational Applications of Artificial Intelligence to Real World Problem Solving

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Abstract

Teaching the course of Artificial intelligence to undergraduate students can become more efficient when real world examples of applications developed as simulations are used in the form of educational resources. Such applications can be developed by students at their diploma project or at the semester project, under the supervision of the professor that teach the course of Artificial Intelligence who can distribute some thematic subjects according to the chapters of the course. Thus, next generation of students can learn from the experience of previous generation of students. The paper presents two educational applications of artificial intelligence to real world problem solving, developed by students from the Computer Science specialization of the Petroleum-Gas University of Ploiesti at their diploma project: an air pollution prediction system based on deep learning and a cooperative multi-robot system simulated in Webots.

Keywords: Educational application, Artificial intelligence, Deep learning, Multi-robot system coordination

1 Introduction

In the last decade, it was recorded a significant increase of artificial intelligence applications to various real world problems solving from almost all domains, reflected by the number of research papers published in the specialized literature. This fact has grown the students' interest in studying the course of Artificial Intelligence (AI) and also, the necessity for teachers to adapt the AI course to the current trends in the domain, according to the academic study program, and their pedagogic-methodological approach.

A solution can be given by the inclusion in the AI course resources of some real world educational applications developed as simulations by students of current academic year generation and used by next academic year students generation. Such applications can be developed by students at the semester AI project or at their diploma project, under the supervision of the professor that teach the AI course and manage the projects' topics distribution. Starting from this idea, the paper presents two educational applications of AI developed as simulations by undergraduate students from the Computer Science specialization at the Petroleum-Gas University of Ploiesti for their diploma project, presented in July 2020.

The paper is organized as follows. Section 2 briefly presents basic issues and current trends in the domain of AI. Two educational applications of AI approaches are detailed in section 3, an air

pollution prediction system based on deep learning and a cooperative multi-robot system simulated in Webots. The final section concludes the paper.

2 Artificial Intelligence: Basic Issues and Current Trends

Artificial intelligence is a vast domain, under continuous development, intersecting other domains such as Computer Science, Computer Engineering, Robotics, Mathematics, Philosophy, Physics, Biology. During the AI history (of almost 70 years), a variety of distinct fields were included in the AI domain: machine learning, case-based reasoning, knowledge-based systems, expert systems, pattern recognition, intelligent robots, intelligent agents, multi-agent systems, artificial neural networks, genetic algorithms, swarm intelligence etc. Basically, two types of approaches are used by AI: symbolic logic based approaches and computational intelligence approaches. The approaches of first type are part of the traditional or classical AI in which knowledge and reasoning are fundamental, while the second type is oriented more on computation models that copy different natural systems.

Among the current general trends in the AI domain we mention two:

- The development of new computational intelligence techniques (usually, nature-inspired – improved versions of ant colony optimization, particle swarm optimization, artificial bees, grey wolf optimizer, firefly and new techniques) that are applied to solve real world complex problems (e.g. optimization problems from engineering).
- The development of new intelligent systems that apply various AI methods and techniques (e.g. intelligent manufacturing systems, intelligent renewable energy systems, intelligent tutoring and learning systems for universities).

Some specific trends are: the development of more powerful machine learning methods, as for example, deep learning, and the design and implementation of intelligent mono and multi-robot systems for industry (as e.g. automotive).

Engineering is one of the general domains that frequently applies AI techniques. We have selected some examples of AI engineering applications:

- Smart manufacturing (Cioffi et al., 2020);
- Robotic welding process control with artificial neural networks (Bucur et al., 2002);
- Air quality prediction with deep learning (Freeman et al., 2018);
- Intelligent multi-robots systems coordination in flexible manufacturing (see the examples given in the survey (Cortés and Egerstedt, 2017));
- Knowledge based systems for optimal process control (the Expert_AT system described in (Oprea, 2017));

Education is also a general domain where AI was applied and more applications can be developed in the future. A critical analysis of the research that reported AI applications in higher education is made in (Zawacki-Richter et al., 2019). The authors identified in the literature four areas of AI applications for institutional services, academic support services, and administrative services: profiling and prediction; assessment and evaluation; intelligent tutoring systems; adaptive systems and personalization. They highlighted several problems such as the risk of using AI in education and the weak connection to the theoretical pedagogical perspectives.

3 The Educational Applications of AI

One of the best textbooks in teaching AI is *Artificial Intelligence - A Modern Approach*, its last edition appeared this year (Russel and Norvig, 2020), written by Stuart Russel and Peter Norvig. This book covers the important fields of AI and presents apart from the theoretical and historical issues, examples and applications of the described methods. We are using this textbook as a basic reference for the Artificial Intelligence course taught in the fourth year to undergraduate students studying Computer Science. Also, we have used in the last three academic years the book (Oprea,

2017) in which are described some intelligent systems developed at Petroleum-Gas University of Ploiesti under research projects. These applications are used as educational resources for teaching the AI course. More educational applications were developed by students for their semester AI project or their diploma project.

We have selected two diploma projects that were developed by two students in the academic year 2019-2020 and were presented in July 2020, with topics from machine learning, and intelligent robotics.

3.1 Deep learning application

The first application tackles the problem of air pollution prediction with an AI method, deep learning. Starting from the need of a reliable predictive system, that provides more accurate forecasts of air pollution, the BSc Thesis (Vartan, 2020) describes how such a system was developed using the latest technologies in the fields of Artificial Intelligence and Artificial Neural Networks (Aggarwal, 2018). The dataset for this application was created during a three months' period from the 23rd of March up to July 8th 2020 by collecting data of atmospheric pollutants concentrations measured by the air pollution monitoring stations of The Romanian National Air Quality Monitoring Network (http://www.calitateaer.ro).

The neural network that made use of this dataset has been designed and implemented with the Python programming language. The choice was made in favor of this language because it provides the best support regarding all manners of artificial intelligence applications and data science and a sizeable collection of modules, libraries and tools necessary for deep learning. The IDE on which the application was developed is known as Jupyter Notebook, a program from the Anaconda Python distribution. In the predictive application the newest versions from Keras, Pandas, Matplotlib, Tensorflow and Scikit-learn software tools have been put to use in order to create a neural network. First, the dataset containing 845 entries has been inserted into the program, converted into an array and later preprocessed using the min_max_scaler function. The artificial neural network's architecture was in essence a sequential model of a deep artificial neural network (i.e. a feed forward artificial neural network with more hidden layers for deep learning), that contains the input layer, two hidden layers of 32 neurons each activated by a ReLU function and an output layer activated by a sigmoid function.

Figure 1 shows the structure of the artificial neural network that was used as prediction model.

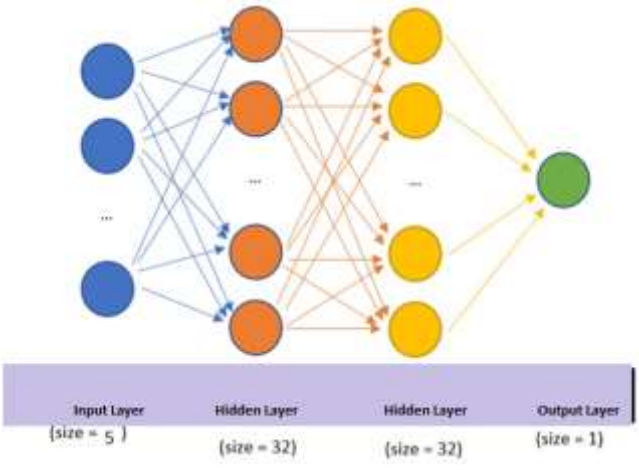

Figure 1. The prediction artificial neural network structure

The model has been optimized using the stochastic gradient descent method, and the loss function used was mean squared error (MSE). The model has been trained for 100 epochs and so far the accuracy of the neural network model has increased from 60% up to 76% due to repeated runs of the same dataset. Figure 2 shows the accuracy of the mathematical model for two tests run.

Figure 2. The accuracy of the mathematical model for two tests run

The developed predictive system offers a satisfying accuracy and prediction in order to combat one of the most pressing matters of the modern world: atmospheric pollution.

The main benefits highlighted by the student that developed this application were: a comprehensive understanding of a deep artificial neural network model design and implementation with some free software tools for a real world application, that of air pollution prediction in urban areas, with real datasets of air pollutants concentrations. Apart from learning a specific prediction problem solving AI-based method (deep learning), the student learned new software tools, as well as how to program in Python language.

3.2 Cooperative multi-robot system application

The second educational application focuses on intelligent multi-robot systems that can cooperate to perform certain tasks. In such intelligent systems, the robots has sensors and actuators and they can be coordinated to solve real world problems by cooperation. Starting from the current trend in the field of Intelligent Robotics that of developing intelligent cooperative multi-robot systems in various industrial fields for carrying complex tasks, systems that have a higher performance in comparison with single robot systems, the BSc Thesis (Vatamanu, 2020) developed an educational application that solve a problem of transport and storage with an intelligent multi-robot system implemented as a simulation in Webots, a robot systems simulation software package. The system is composed of three e-puck mobile robots (see Figure 3), two cooperative robots that transport by pushing a box to a certain location, and one robot that takes the box from the location where it was transported by the other two robots and perform box transportation and storage to a known location.

Figure 3. The e-puck mobile robot model in Webots

The e-puck robot has position sensors, proximity sensors, light sensors, camera, accelerometer, ground sensors.

The experiments that were run in Webots showed a good performance of the multi-robot system in solving the proposed problem in terms of task completion time. Figure 4 shows an example of working environment simulated for this application. This is actually the start configuration of the working scene for our experiment. The two mobile robots that perform the transportation task by pushing the box follow a simple navigation algorithm, while the third robot has a more complex navigation algorithm that performs obstacle avoidance with some basic mobile robot motion functions (see code in Figure 5).

Figure 4. An example of working environment simulated for the multi-robot system

```
void turn_right(WbDeviceTag left_wheel, WbDeviceTag right_wheel)
{
  wb_motor_set_velocity(left_wheel, 4.0);
  wb_motor_set_velocity(right_wheel, 0.0);
}

void turn_left(WbDeviceTag left_wheel, WbDeviceTag right_wheel)
{
  wb_motor_set_velocity(left_wheel, 0.0);
  wb_motor_set_velocity(right_wheel, 4.0);
}
```

Figure 5. Example of some basic mobile robot motion function code

Figure 6 shows the next three steps toward cooperative multi-robot system task completion as a simulation for solving the box transportation and storage problem.

Figure 6. Steps toward cooperative multi-robot system task completion

The main benefits emphasized by the student that developed this application were: a comprehensive understanding of some mobile robot navigation and coordination algorithms, the design of the multi-robot system for a real world problem (transport and storage), and its implementation as a simulation in Webots, an educational and research free software tool.

Conclusion

The paper presented two educational applications of artificial intelligence to real world problem solving developed as simulations by Computer Science undergraduate students at their diploma project. The approaches that were used in the two projects, deep learning and cooperative multi-robot systems are currently among the challenges research topics in applied AI. The two simulated applications will be included as educational resources for the AI course that will be taught to the next academic year students from the Computer Science program of study, facilitating a better understanding of specific artificial intelligence methods.

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