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Discuss the applications and the benefits of Artificial Intelligence (AI) in the energy sector

Contents

Introduction:

Owing to the capability of AI to sense, engage, reason, and learn, a growing number of industries including the energy sector are implementing AI technology into their operations. The versatility of AI technology enables the energy sector to get better in a variety of ways. For example, it can improve workplace safety by identifying hazards such as cracks and corrosion, reduce greenhouse gas emissions by measuring the emissions at both macro and micro levels, increase the security of the operating system by preventing cyberattacks, enhance the productivity of companies by gathering data, and ameliorate power management by enabling the communications between smart meters and other devices. In the following paragraphs, I will be discussing the applications and benefits of four aspects of AI in the energy sector.

i) How robotics & motion is used in the energy sector:

Robotics involves the design, manufacture, implementation, and operation of robots. A variety of human jobs could be assisted by it with high efficiency. One of its applications is in the solar panel industry.

ABB ltd. designed a robot arm that increases the production rate of solar collector panels from 3 panels per day to 240 panels per day, which is now adapted by Absolican's solar technology firm (*ABB news,* 2021). The CEO of Absolican claims that by using robotic technology, they were able to develop an automated production process that significantly lowers production costs by using less labor while still being able to produce products of a high caliber.

Figure 1- A robotic arm (ABB news, 2021)

Curtis Berlinguette and his colleagues have created a robot, Ada, that can generate new materials using optimization algorithms (MacLeod et al., 2020). Ada combines various chemical solutions, molds them into thin films, processes them with heat and other methods, tests the conductivity of the films, assesses the film's structures, and records the results. Ada speeds up the process of finding defect-free material for solar panels from 9 months to only 5 days (MacLeod et al., 2022).

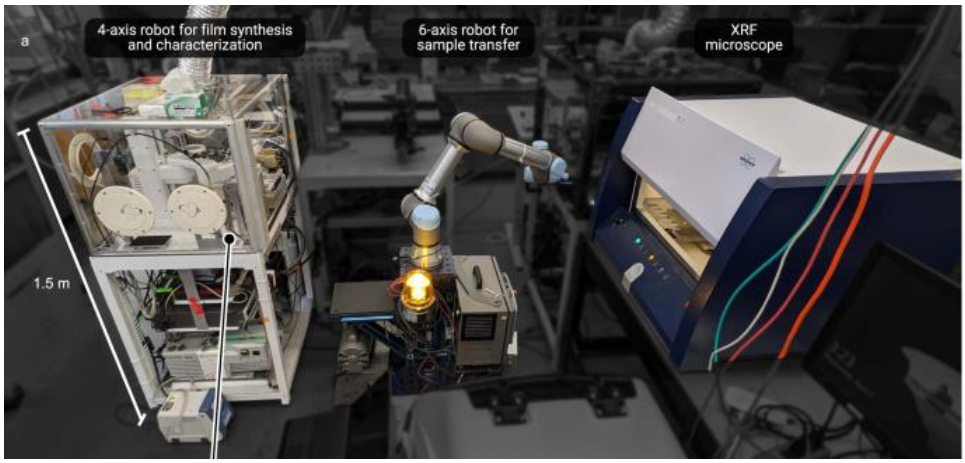

Figure 2- The Ada self-driving laboratory and autonomous experimental workflow (MacLeod et al., 2022)

A heliostat-orienting system was developed by the Applied Automatics laboratory at the University of Mohamed Bougara utilizing a PLC-based robot manipulator (Chaib et al., 2013). solar can track the movement of the sun's radiation based on the calculated results of the sun's position on earth at any time by a program made by MATLAB software, and the robot manipulator will control the orientation of the solar panels based on heliostat, to maximize the solar energy absorbed by the solar panels. As a result, the efficiency of solar energy generation will rise, reducing the need for energy produced from fossil fuels and resulting in lower greenhouse gas emissions.

ii) How computer vision is used in the energy sector:

Computer vision is a technology that allows computers and systems to extract useful information from visual data inputs like films and photographs. It is used in performing jobs that normally require human visual perception and classification.

A team successfully developed an automatic leak detection technique for methane emission (Wang et al., 2020). They integrated convolutional neural network (CNN) modeling with infrared optical gas imaging (OGI) cameras and trained on methane leak images. The new method allows the absence of operators' judgment on the detected images, which improved human error and labor. Additionally, it assisted companies in tracking methane emission levels, so the impact of using natural gas on the climate could be reduced.

IEEE has announced that the inspection of photovoltaic power (PV) plants is now possible with the use of computer vision (Addabbo et al., 2017). Abnormal PV panels can now be detected and marked, and the defective panels can be identified thanks to the fusion of Unmanned Aerial Vehicles (UAVs), geometric data collected by high accuracy Global Navigation Satellite System (GNSS), and the outcomes of a computer vision template matching algorithm applied to thermal images. This technology helps PV

owners to maintain their panels as they will be able to replace the degraded panels to ensure the performance of the PV plant.

The Journal of Petroleum Exploration and Production Technology has published an article that proposed a method for determining interfacial tension for oil field applications (Gupta et al., 2021). First, take a picture of a drop of the reservoir fluid. Then, apply the picture with grayscale and use the contours tool in OpenCV (a computer vision library) to finalize the picture taken. Finally, calculate a few of the drop's geometrical properties to get information that will be beneficial in determining the interfacial tension. The interfacial tension indicates the difficulty of oil movement from the porous structure of the rocks, which benefits the petroleum industry by allowing them to design a more effective and economical process for oil recovery.

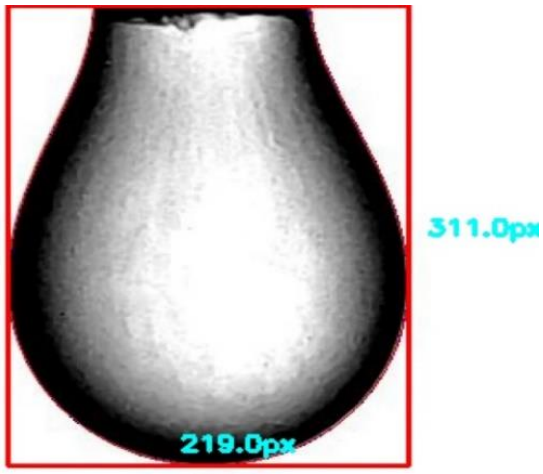

Figure3 3- Grayscale image of reservoir fluid (Gupta et al., 2021)

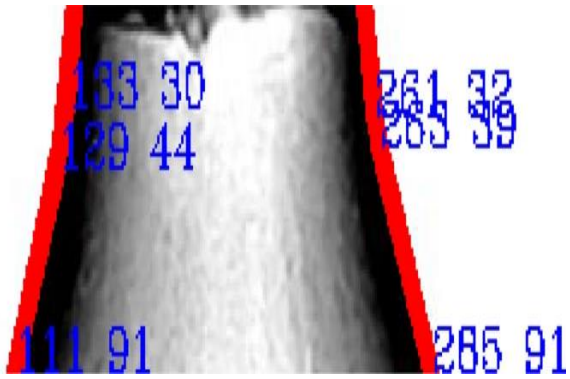

Figure4 4- Measurements of the fluid (Gupta et al., 2021)

iii) How machine learning is used in the energy sector:

Machine learning (ML) is the ability of computers to acquire and adapt to random situations without following direct instructions. More specifically, “A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.” (Mitchell, 1997)

Members from the University of Washington presented a method to forecast the electric load in 1991 (Park et al., 1991). Artificial neural network (ANN) is used to trace prior load patterns and anticipates a load pattern using recent load data. The newly suggested method requires inputs of weather information, and ANN is capable of non-linear calculations. The older method requires inputs of time or temperature but can only do linear calculations, which fail when other additional variables are added, such as humidity and cloud coverage.

A research group from Riga Technical University proposed an algorithm predicting short-term wind generation (Shabbir et al., 2019). The team employed a Support Vector Machine (SVM) based regression algorithm to predict the wind energy production in Estonia one day ahead. The result is compared with the result of the actual production of winds, which showed improved accuracy compared to the previously adopted algorithm. The prediction helps companies to find a balance between the supply and demand of wind power.

Researchers from Switzerland suggested energy could be saved without sacrificing comfort with the help of smart homes (Schweizer et al., 2015). A novel pattern mining algorithm called Window Sliding with De-Duplication (WWSD) is designed, is meant to be able to learn how users use energy and report both frequent and periodic pattern data, and a recommender system implemented on a cloud-based Microsoft® Azure Virtual Machine (VM) is adopted by the team, after which the data may be uploaded to the file server. The recommendation can help users save money on their energy bills by reminding them to turn off appliances that are not in use.

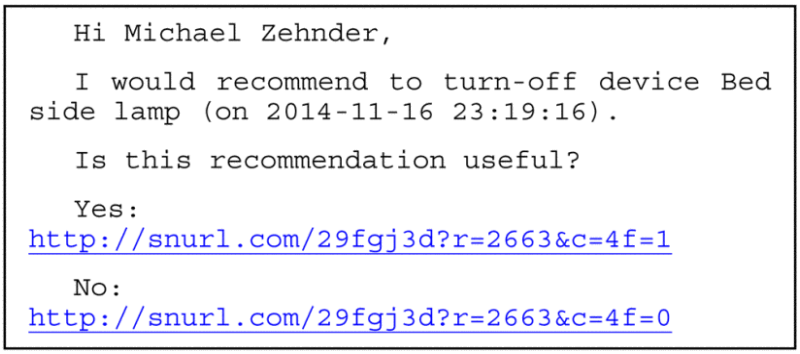

Figure5 5- Recommended action on saving energy (Schweizer et al., 2015)

IV) How natural processing language is used in the energy sector:

Natural language processing (NLP) is a form of AI that enables computers to comprehend human semantics. It is extremely common to assume that NPL is just utilized in the information technology sector, instead, it can also help the energy sector.

Marcelo Guarido and Daniel Trad use NPL to predict the severe injuries of workers in the oil and gas industry (Guarido & Trad, 2019). The goal is to categorize the type of injury based on how the injury is described in the describer's native tongue. The descriptions are then converted into numerical values using the TF-IDF algorithm, and the value is compared to data from a reference set. Locations and the most prevalent injury types are analyzed to help the prediction. Using the prediction model, energy businesses and governments might standardize the classification of injuries and take steps to reduce worker safety risks.

Students from Wuhan University have invented multi-step prediction methods based on transformer architecture in NLP for the prevision of wind power (Wang et al., 2022). First, collect wind power (WP) and numerical wind power (NWP) data as inputs and separate them into 3 data sets -- Training set, validation set, and trial set. Then, find nominee transformer models contains various combinations of hyper-parameters. Afterward, assess nominee models on the validation set after training them on the

training set. Moreover, choose the best Transformer model with the most accuracy, then examine it on the trial set data. To analyze the predicted findings in conjunction with the evaluation indicators, de-normalize the estimated data to receive the WP predictive value. This process has decent accuracy for ultra-short-term (minutes as a unit) multi-step wind power predictions, which allows energy company to make better business decisions.

Conclusions:

AI has become a trend in many industries including the energy sector. Robotics, computer vision, machine learning, and natural language processing are some of the AI technologies that are most frequently utilized in the energy industry. There are numerous benefits to using AI technology in the energy business. In robotics, the production rate of solar panels has increased, materials research for solar panels has accelerated, and solar energy generation has been maximized. Computer vision has enabled automatic leak detection of methane emissions, inspection of photovoltaic power plants, and determination of interfacial tension in oil field applications. These applications improve efficiency, reduce human error, and contribute to the maintenance and optimization of energy systems. Machine learning techniques have been utilized for forecasting electric load and wind energy generation, helping companies find a balance between supply and demand. Smart homes equipped with machine learning algorithms allow for energy savings without sacrificing comfort. Natural language processing has been employed for injury prediction and classification in the oil and gas industry, as well as multi-step prediction of wind power based on transformer architecture. Overall, these advancements in AI have improved efficiency, lowered the costs, and enhanced the accuracy of data produced in the energy sector.

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