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# APPLICATION OF GAN NEURAL NETWORKS IN TRAINING OF VISUAL FIRE DETECTION SYSTEMS

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***Abstract*. Current paper presents an application of Deep Neural Networks in the field of generating new data using GAN. GAN neural networks are very effective in tasks related to the creation of new types of content which makes them highly effective means of simulating and creating objects in an existing images or completely new images. The main characteristics and system architecture of GAN Neural Network are considered.**

***Keywords: Deep Neural Networks, GAN, Data amputation***

## I. INTRODUCTION

Over the last decade the United Nations has pointed out that the problem of uncontrolled phenomena such as fires is so important that efforts need to be stepped up to take preventive measures. In this regard, research aimed at the best possible understanding of the mechanisms of occurrence, detection and extinguishing of fire [1]. According to numerous studies, climate change, especially global warming, is contributing to the development of fires. They pose a major risk to countries, especially Mediterranean countries such as France, Greece, Spain and Portugal. However, frequent fires have been reported in recent years in other parts of the globe (eg Australia, Russia and Canada) [2]. Fires endanger the safety of people and animals, as well as cause significant environmental and material losses (eg forest fires, destruction of buildings and industrial facilities). The costs incurred in extinguishing the fire are estimated to be excessive, reaching hundreds of millions of dollars. The scale of the threat can be illustrated by the 300,000-hectare fire that broke out in 2009 in Australia (200 people were killed at the time) and the fires in Russia in Siberia. Another example is a fire that broke out in early July 2017 in British Columbia (Canada). Although it initially covered an area of 2 hectares, it ignited another 56 fires a day later. Up to 158 fires were registered in British Columbia by 12 September 2017, with devastation covering a record 1.3% of the province's acres [3]. It is estimated that fires annually burn up to 10 000 km2 of vegetation in Europe and 100 000 km2 in North America and Russia [4].

In recent years, the use of the so-called pure fire extinguishers, which consist, according to NFPA (National Fire Protection Association) standards, of appropriately selected fire-extinguishing gases, especially halogenated hydrocarbons and inert gases [5,6]. The disadvantage of using traditional extinguishers is mainly due to their short-time work and the fact that it is practically impossible to quickly fill the tank to be used the same extinguisher repeatedly the site of a fire.

The problem is so significant that the search for new ways to detect and fight fires has begun. One of these ways is with the help of acoustic waves, and the first experiments in this area were in the 90s. The results have been materialized in several publications and patents [7,8]. Studies to analyze the quenching capabilities of acoustic waves have also been conducted by the US agency DARPA since 2008 [9]. A year earlier, it was proven that flames could be extinguished by human voice, but the required sound pressure level exceeded the pain threshold of the human ear, which disqualified the technique from practical use at the time [10]. Studies on the use of acoustic waves are extended and then in 2010 [11,12]. The tangible results of the work are patents that have already received protection [13 - 16].

With the help of DNN (Deep Neural Networks) networks it is possible to be designed an automatic fire detection and control of fire extinguishing systems [17,18]. The correct detection of fires depends largely on how successfully the neural networks are trained.

The training uses a large number of images of fires that occurred under different conditions - in forests, buildings, interiors and more. The conditions and objects contained in these images are not the same as the conditions of the image that will be obtained from a real fire detection camera.

The idea of the present study is to propose an algorithm based on GAN (Generative Adversarial Network) networks, in which the fire detection system can be trained with generated images of fires overlayed on the real images, which are captured with the corresponding camera.

## II. MAIN CHARACTERISTICS OF GAN NETWORKS

Generative-racing network (GAN - Generative adversarial network) represent a change in the architectural design for deep neural networks [19,20]. There are several advantages of using this architecture: it can perform generalization in limited data to create new content from small data sets and also makes the simulated data to look more realistic.

This is extremely important as a feature in the field of so-called Deep Learning, because most methods today require large amounts of data. Using this new architecture, it is possible drastically be reduced the amount of data needed to perform these tasks. In extreme examples of GAN architectures, they can use only 10% of the data needed to solve problems in deep learning compared to other methods. The main parts of GAN networks are the so-called generator and discriminator. The generator and the discriminator work as follows:

Purpose of the generator: to generate new content that looks real.

Purpose of the discriminator: based on the image generated by the generator and the real one, the discriminator determines whether the generator generates images correctly and reliably.

The training logic is as follows: the GAN generator will start training together with the discriminator; the discriminator must train for several cycles (epochs) before starting competitive training, as the discriminator will need to be able to actually classify the images.

The part of the generator is shown in Fig. 1.

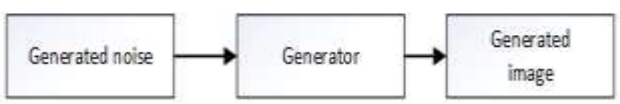


**Fig.1.** GAN generator

The discriminator is shown in fig . 2.

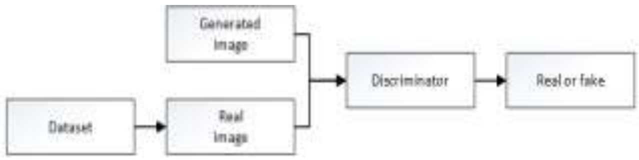


**Fig.2**. GAN discriminator

The overall GAN architecture is shown in Figure 3.

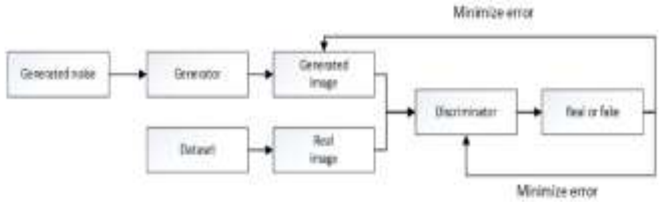


**Fig.3**. GAN

## III. SYSTEM ARCHITECTURE

In this article, related to forest fire detection, a GAN network has been trained to be able to generate fire on incoming images. CycleGAN architecture was used to generate images with fire. It is a collection of 2 GAN neural networks [21]. Each GAN has a conditional generator model that will synthesize an image with a given input image. And each GAN has a discriminatory model to predict how likely it is that the generated image came from the target image collection. The discriminator and generator models in GAN networks are trained at the same learning rate. Each GAN is updated using consistent loss function. It is designed to resemble the synthesized images that are read from the input image. Consistency loss compares the input image with the generated image and calculates the difference between the two using the summed absolute difference in pixel values.

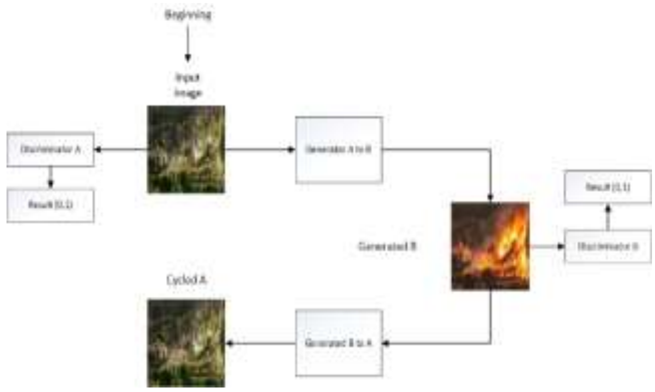


**Fig.4**. CycleGAN architecture

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*USED LIBRARIES*

The following Python libraries have been used to implement the system:

- Numpy is a library that allows developers to work with multidimensional arrays. With NumPy, it is possible to visualize images as multidimensional data arrays . With the built-in mathematical functions of NumPy at a high level, it is possible to perform a quick numerical analysis of the image [22] .

- Matplotlib - a library for data analysis and visualization [23].

- TensorFlow is an open-source machine learning platform [24]. It features a comprehensive, flexible ecosystem of tools, libraries and resources that allows researchers and developers to use the most advanced achievements in machine learning and easy to build and deploy applications using machine learning and various types of neural networks.

*NEURAL NETWORK TRAINING*

There were used 950 photos with a resolution of 256 x 256 and a GTX 1080 Ti video card accelerating the training process and to train the GAN neural network. For every training 100 epochs it is done an assessment of the results of training showing images of a wood area before and after using the neural network. Figure 5 shows photos fed to the input and received at the output of the GAN network, showing how nature would look like in a fire.

**Fig.5.** GAN training results

*VERIFICATION OF NETWORK OPERATION*

For experiments related to the verification of the work of the trained network, a test set was used, which is not included in the process of its training.

An unknown image of a forest area is fed to the input of the GAN network and a generated image with a simulated fire is obtained at the output.

An example of the verification process is the image shown in Fig.6.

**Fig.6**. Original image before GAN

The result of the operation of the neural network is shown in Figure 7.

**Fig.7**. Image after GAN

As seen from the figure 7, the GAN generates fire which seems convincingly real. It can be seen that the GAN network has also managed to generate fire covering the tree trunks in the forest area, which fully confirms the possibility of simulating the type of forest fires with the help of neural networks.

## IV. CONCLUSION

GAN neural networks are very effective in tasks related to the creation of new types of content which makes them highly effective means of simulating and creating objects in an existing images or completely new images.

The ability to simulate a fire on an existing image makes it possible to obtain preliminary expectations of what a certain area would look like when observed with a video camera in the event of fire and flames. This prior knowledge can help to develop advanced artificial intelligence systems that can detect fires in the area they are monitoring with great accuracy.

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