Combination of Variational Autoencoders and Generative Adversarial Network into an Unsupervised Generative Model

Ali Jaber Almalki and Pawel Wocjan

1 Introduction

Human developed the mental model based upon the environment and things they perceive on a daily basis. On a daily basis, we perceive different things based upon the actions and experiences. Human gathers a lot of information, and the human mind learns the temporal and spatial aspects of the knowledge they gained from their environment. Human brains learn the abstract representation of the information. For example, if we can capture a scene in our and remind it later, we will only remember the abstract information of the particular scene. The internal predictive model influences actions and decisions [1]. One way to understand the predictive model that the current action predicts the future actions we performed that create sensory data. Based on the human internal model, the human brain predicts because of the abstract information representation.

Reinforcement learning is the subfield of the machine language that helps to perform the task with making much effort. In reinforcement learning, the agent can be trained according to the environmental actions, and agents can train in the simulating environment. In the world, using learned features, the agent can be trained in a manner that helps to solve complex and challenging problems [2]. The procedure includes the multistep training process in which each process combines the next one in the training of the agent. In the first step, the information collected in the form of abstract representation and stores the data to perform some action. The actions are made based on the previous choices made by the agent.

Many reinforcement learning problems can be solved when combined with Artificial Intelligence (AI) that help to solve complex tasks. An AI-reinforcement

A. J. Almalki (✉) · P. Wocjan
Department of Computer Science, University of Central Florida, Orlando, FL, USA
e-mail: Ali.almalki@knights.ucf.edu; wocjan@cs.ucf.edu

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learning agent helps to control the complex situation, and the agent performs to gather accurate results with problem handling. Moreover, the AI-reinforcement learning agent helps the predictive model (M) to make better prediction results [3].

The Backpropagation algorithm is used for the predictive model that includes neural networks as well. With the neural network in the predictive model, it helps to produce a better result that supports the prediction accuracy. In the partial observable environment, it is better to use a predictive model with RNN, as it produces better accuracy results and solves complexity effectively.

Most of the reinforcement learning approaches are based upon the model and require a special environment to train the agent. In the world, we have added the GAN discriminator that helps to produce better results and learn in a simulating environment. We have trained the agent in an environment in which the real data can directly go into the GAN/discriminator that make prediction accordingly.

With the combination of GAN/discriminator and MDN-RNN(M), it provides the simplistic approach that helps to train the agent in its own simulating environment and perform well in the complex pixels' detection environment [4]. Previously, the traditional methods were not efficient to help to solve the complex issues of the environment.

2 Related Work

Different existing models of RL help to train the environment and provide generated output. Most of the approaches are based upon the model that learns the environment first and then train the agent to get the task performed quickly. It involves different types of data that process accordingly to gather the output. For the complex data, of the data distribution like images, it involves the image-preprocessing system that helps to convert them into the form that is easily understood by the agent to learn the environment. It helps to formulate a complex task with simple solutions [5]. But when it involves highly complex data, it makes the process of converting the images slow, and normalization of the gathering of the image pixels become difficult to handle. The preprocessing image operations are viewed as the metric engineering that make the process slow when they are bombarded with the highly complex data.

In Siamese architecture, neural networks are used for metric learning. For a similar sample, it minimizes the total distance, but for the dissimilar sample, it maximizes the distance and makes the entire process more complex. But the real problem using this approach is that it can't be applied directly to the problem [6]. This approach can only be applied to the supervised environment.

For the element-wise distance, there are different techniques used that help to measure the distance. For the element, a wise distance-measuring generative model developed that supported in calculating the distance. When the data include the complex images, it becomes difficult to maintain the whole system and autoencoder used that processes the grayscale images. From the edges and shapes, it learns the

type of image. Moreover, GAN-based generative model used for the learning of the images helps to gather the data of sharp edges of the images.

Another generative model introduced that is based upon the gradient and combination of the GAN is used for the video prediction of the animated images. It captures the structure of the images, but when it comes to capturing the high-level structural images, it deformed the data and error occurred. To remove this problem, the GAN generator used that help to produce high-quality images.

From the latent representation, a convolutional network used that process to produce the high-structural quality of the images. Using the simple arithmetic expression, it helps to express the semantic relationship. Another technique that is supervised training that is commonly used in the convolutional network helps to define the high-level information.

For the feature representation of the data encoder and decoder used, and it uses the supervised information—the training of the data dependent upon the supervised learning of the data used for sampling. But the problem with this technique is that it can't take the visual data of the pure GANs.

Different dynamic models exist in which they train the model policy, and then apply the experimental procedures. Probabilistic Search Policy used that help to solve the controlling problem based upon the data collected from the environment. It uses the Gaussian Process that understand the system dynamic and train the system to take control to perform desired tasks effectively.

Bayesian Neutral Network is another way to learn the Dynamic Model. The Bayesian Neutral Network is more efficient than the Gaussian process. It performs more effectively and produces promising results for the controlling task. It observes a low-dimensional process, and all of the starting and ending states are well defined. To stimulate the environment of the game, the Conventional Neural network is used to solve challenges and provide complete control to the user [7]. It helps to predict the future behavior of the agent-based upon the data gathering of the stimulating environment.

RNN models are powerful and that helps to predict future behavior, and the next frame of the game can easily be predicted using the RNN models. Moreover, if there is an internal model used, RNN supports the internal model and generate future predicted frames. To control the controlled and perform the required tasks, evolution strategies used that cooperation in the multilevel environment, which means it supports the multiple agents working in the same environment.

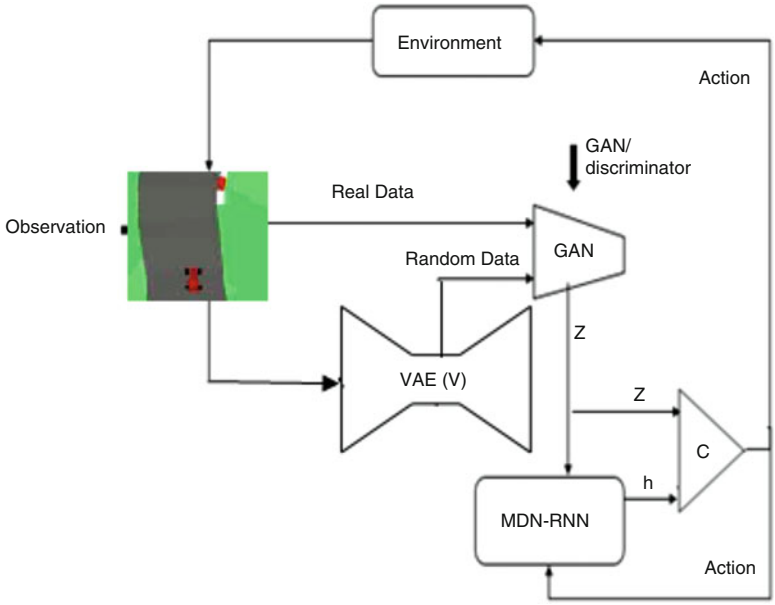
Traditional Deep Reinforcement Learning Method is not efficient because it can't offer control to multiple agents in the same environment. To handle the multilayer control evolution-based algorithm used that reading to direct data based upon the environment and predict the behavior of the agent effectively. With the evolutional algorithms, the complex tasks can solve easily and better prediction it produces.

3 Agent Model

A simple model represented in which the combination of the GAN and VAE shown that helps to produce better accuracy results. In this model agent has a small visual component that visualize the better representation of the code. It has a small that helps to store the data and can make accurate future prediction. The future prediction is based upon the historical information it gathers from the environment [8]. There is a separate component of the observation that helps to observe the simulating environment. This model provides the better control to the agent for making the decisions. The decision taken by the agent based upon the visual representation and the data stored in the memory.

In this model, the three-component work closely to collect the data and make better decision that helps to calculate the accuracy of the data. The three main controllers are vision, memory, and controller.

The major contribution to this model is that VAE and GAN are combined that produce better accuracy results. It compares the datasets and generate results with better imaging quality. Generative models are trained that produce quality imaging results.



4 VAE (V) Model

The environment in which the agent got trained receives the quality input and with each time frame it receives the input data in form of 2D image. The V component helps to compress the data size and learns the environment into an abstract form [9]. Variational autoencoder (VAE) used and V play an important role in which they compresses the size of the images for the better accuracy results. Each time the agent observes the data from the environment, it compresses the size of the image into the small latent size z.

5 MDN-RNN (M) Model

The role of the V model helps to compress the size of the images in to the latent and produce better imaging results for sampling. It reduces the size of what the agent observes in its environment. But the MDN-RNN helps to predict the future as per the agent movement. It predicts the data of what going to next happens.

The M model supports as the predictive model that make prediction according to the agent performance in the environment. Gaussian distribution used for the sampling a prediction dependent upon the model V. The M model provide the prediction results based upon the past and current information received from the V model. Mixture density network combined with the RNN to gather the better prediction.

The combination of the both MDN–RNN help to produce better prediction results. Next latent vector can predict effectively and have ability to handle the complex environment effectively. Moreover, during the sampling, the temperature of the parameter can adjust. Using the combinational model of the MDN–RNN, the sequence generation problem that include pen detection and handwriting can handle effectively.

6 Controller Model (C)

The controller model C helps to determine the actions. The C model maximize the controller action of the agent in observing different elements of the environment. It helps to reduce the complexity caused by the Model V and M. It is a simple linear model that hold the control of the agent in performing different actions. The model C advances the deep learning process and practically behaves effectively [10]. It maps the vision observe by the agent in the particular environment. It represents the quantitative representation of the action vector based upon the agent action.

7 GAN/Discriminator

GAN is a high-quality generative model that helps to produce better results. GAN discriminator produces high-quality data even from the hidden layers. GAN is a generative adversarial network that consists of two networks. Using the GAN, it gives better accuracy in results in which it can do by removing the discrimination between the generated and true data.

It uses following set of instructions for running the game based on the GAN–VAN as describe in the table. For demo purposes, we are working with a small dataset of 100 episodes and each episode is of 200 time steps. The original authors had worked with 10,000 episodes of 300 time steps [11].

GAN uses the binary classifiers to remove the discrimination between the generated and true data. It can effectively remove the discrimination between the images and nonimages data. The combination of the GAN and VAE represents a high-quality generative model. The combinational model of both helps to gather the data from the hidden layer as well.

In our generative model, we have to train both GAN and VAN that helps to solves the complexities that traditional models, methods, and techniques fail to handle. GAN provide the accessibility in which it can learn the samples indirectly.

In comparison with the separate resulting of the GAN and VAE, they both provide comparatively low results. But the combination results of the GAN and VAE, the produce better results. The both attributes visually better results and better accuracy sampling images. The generalization of the GAN and VAE model is better and semi-supervised method produce productive results [12].

The working of the whole model in which the observation takes from the environment and the observation take in the form of 2D images. The 2D images take the observation in the form of RGD depth, width, and length. The VAE and GAN autoencoder it into the better result and provide the efficient results by encoding it into the latent size of the image.

The model M takes the previous action and current action, it provides the predictive results. The main goal of this model is to take the future prediction based upon the observation of the environment [13]. The C model is the controller that provide full control to the agent in making the decision based upon the action taken in the environment.

8 C. MDN-RNN (M) Model

The role of the V model is to compress the size of the images to the latent representation and produce better imaging results for sampling. It reduces the size of what the agent observes in its environment. The MDN–RNN (M) model, on the other hand, helps to predict the future as per the agent's movements. It predicts from the data what will happen next.

The M model serves as the predictive model that makes predictions according to the agent's performance in the environment. Gaussian distribution is used to sample a prediction dependent on the model V. The M model provides the prediction results based on both the past and current information received from the V model. Mixture Density Network combined with the RNN to gather better predictions.

The combination of MDN–RNN helps to produce better prediction results. Next latent vector can make effective predictions and it has the ability to handle a complex environment more effectively. Moreover, during the sampling, the temperature of the parameter can be adjusted. Using the combinational model of the MDN–RNN, the sequence generation problem includes both pen detection and handwriting and can handle both effectively.

9 D. Controller Model©

The controller model© helps to determine actions. The C model maximizes the controller action of the agent by observing different elements of the environment. It helps to reduce the complexity caused by Model V and Model M. It is a simple linear model that holds the control of the agent in performing different actions. Model C effectively advances the deep-learning process. It maps the images observed by the agent in the particular environment. It shows the quantitative representation of the action vector based on the agent's action.

10 Experimental Results of Car Racing: Feature Extraction

We have trained the agent world by experimenting it on a car racing game. The new combination of the VAE and GAN gives better results as compared to the previous agent world. The component used in the agent model helps to produce better results and solves the complexities that are available in the traditional agent model.

The agent model component that includes the V and M gives better results and helps to extract the features which are reliable to gather useful information. The agent performs in the environment where it is trained to control the three actions that include acceleration, brake, and steering right/left. The agent performs randomly in the environment in which he performs different states and gather different datasets [14]. Moreover, using the new agent model, it is noticed that the agent can hold the decision effectively and user controls are stable to control the car.

Our agent can achieve the score of 1000 as compared to the traditional methods of the deep learning, wherein the agent is only able to achieve the score goal of 500–600. Moreover, the average score is 900. The combination agent worlds of the VAE and GAN are effective and solve the complexity of the entire system. In contrast

to the traditional, the new agent world offers better results and finer pixel quality [15]. It means it involves more attention of the user and make it more user-friendly. Moreover, it is able to give better future prediction and gives better hypothetical results when it comes to compare the accuracy with the traditional model's results.

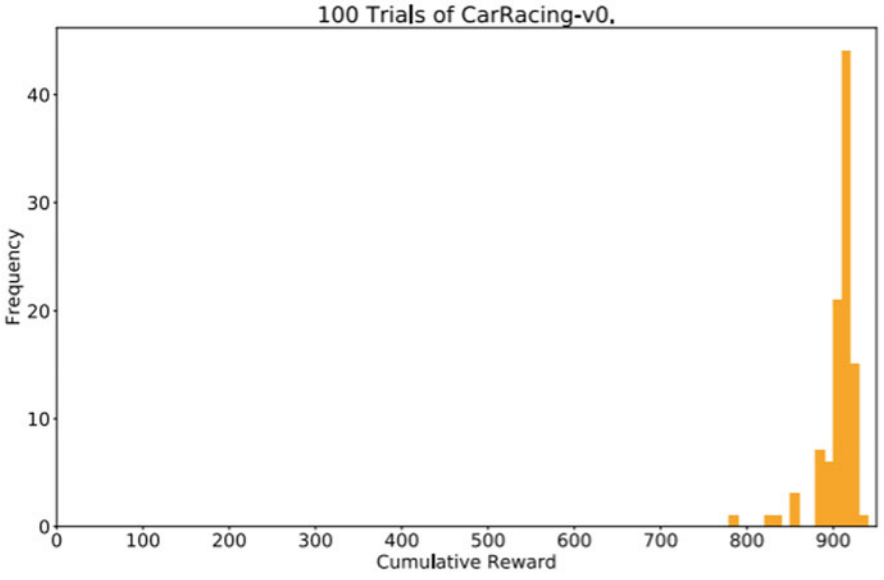
11 Evolutional Strategies and Doom RNN

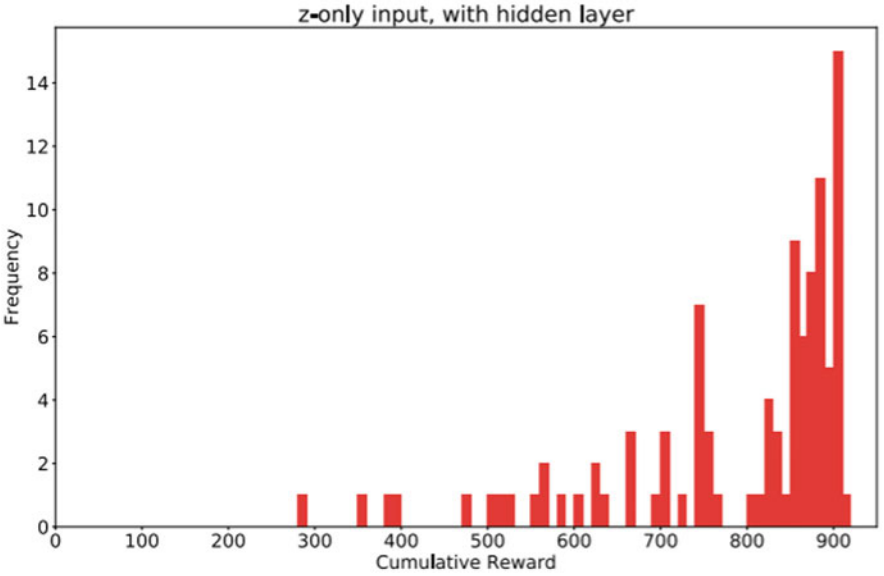
Covariance matrix strategy is based on the matrix and gives results in form of frequency. In combination with the new agent model it improves the results and gives better frequency results.

The population size is of 65, and agent performs the task 18 times. The average score it can make is 950, which is more as compared to the traditional agent training method.

The same experiment performed using the Doom RNN, where it can configure that it can made the averages score of 980 and shows better result performance.

Doom RNN is comparatively more efficient as compared to the traditional approaches used and traditional approaches also slow down the process and make it difficult for the agent to observe the environment directly. Doom RNN with the new agent model shows better controller performance of the agent.





12 Conclusion

For better accuracy result and to gather better visual representation of the images GAN and VAE combined to gather, experiment and perform on the racing game. From the experiment, it is concluded that the scores are better as compared to using traditional algorithms and techniques. Moreover, the experiment performed on the Evolutional Strategies and Doom RNN effectively observed the scoring trend. Doom RNN secured better results and observed that average score is 980. The combination agent world of the VAE and GAN is effective and solves the complexity of the entire system.

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