International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Deep Learning and Its Application in Self Driving Cars

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ABSTRACT

Deep learning (DL) is subset of Machin learning (ML), nowadays considered as a core technology of today's Fourth Industrial Revolution (4IR or Industry 4.0). It has been widely applied in image processing, natural language understanding, and so on. In recent years lot of DL, based applications have been presented in deferent fields, Self-driving cars is one of them. Self-driving cars become hot research topic in science and technology. This paper presents the review of resent reaches on the Deep Learning and its applications in the Self-driving cars. This survey provides a detailed explanation of the Deep Learning and how it is applied in self driving cars to give the solutions of the problems, such as object detection, scene recognition, lane detection, navigation etc.

Introduction

Nowadays, DL technology is considered as one hot topics within the area of machine learning, artificial intelligence as well as data science and analytics, due to its learning capabilities from the given data. DL is considered as a subset of ML and AI. The inspiration of the way that human brain filters the information. There are different layers of algorithms called the artificial neural network. Which is used widely in applied in image processing, natural language understanding, and so on.

Now a days, the rapid development of artificial intelligence has greatly promoted the progress of unmanned driving, such as self-driving cars, unmanned aerial vehicles, and so on. Among these unmanned driving technologies, self-driving cars have attracted more and more attention for their important economic effect. However, there are lots of challenges in self-driving cars. For example, the safety problem is the key technology that must be solved efficiently in self-driving cars, otherwise, it is impossible to allow self-driving cars on the road. To solve these challenges, we can implement the Deep Learning. Which can used to get more and more solution like obstacle detection, scene recognition, lane detection, and so on. This paper explains what is Deep Learning? How it works? And how it is applied in self driving cars.

What is Deep Learning?

Deep Learning is a subfield of machine learning concerned with algorithms inspired by the structure and function of the brain called artificial neural network**.** Simply DL is subset of ML which is used to train computers think like human brain.

The Deep Learning (DL) concept appeared for the first time in 2006 as a new field of research within machine learning. It was first known as hierarchical learning at the, and it usually involved many research fields related to pattern recognition. Deep learning mainly considers two key factors: nonlinear processing in multiple layers or stages and supervised or unsupervised learning. Nonlinear processing in multiple layers refers to an algorithm where the current layer takes the output of the previous layer as an input. Hierarchy is established among layers to organize the importance of the data to be considered as useful or not. On the other hand, supervised and unsupervised learning is related with the class target label, its availability means a supervised system, whereas its absence means an unsupervised system.

Nowadays, artificial intelligence (AI), ML, and deep learning (DL) are three popular terms that are sometimes used interchangeably to describe systems or software that behaves intelligently. In Fig, we illustrate the position of deep Learning, comparing with machine learning and artificial intelligence.

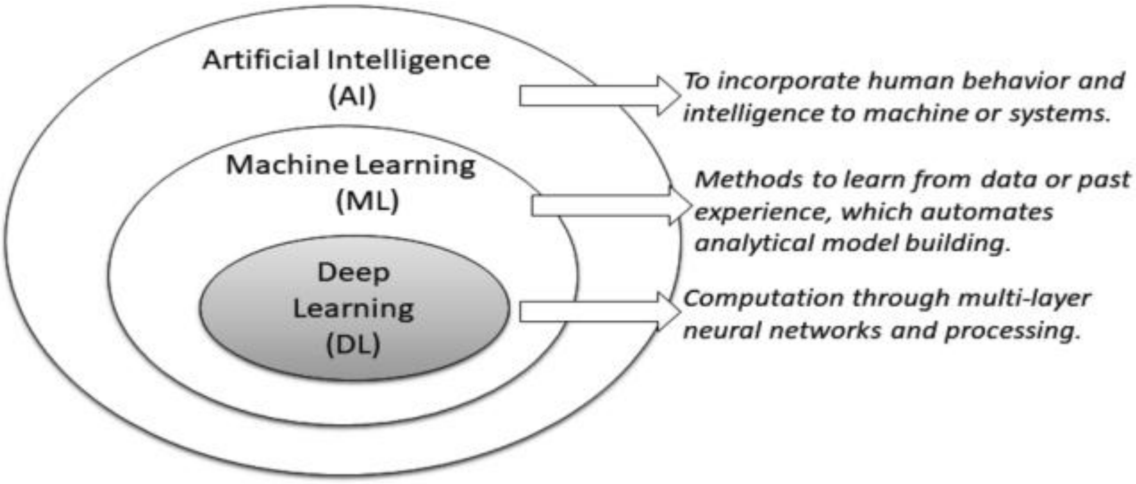


Fig.1 An illustration of the position of deep learning (DL), comparing with machine learning (ML) and artificial intelligence (AI)

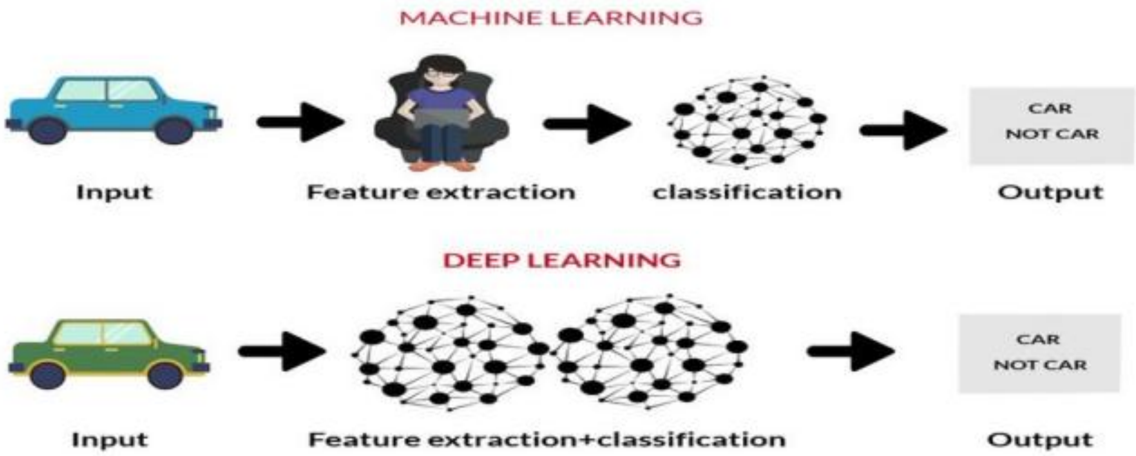


Fig.2 the difference between deep learning and traditional machine learning

Why deep learning?

Several performance features may answer this question, e.g.,

1. Universal Learning Approach: Because DL has the ability to perform in approximately all application domains, it is sometimes referred to as universal learning.

2. Robustness: In general, precisely designed features are not required in DL techniques. Instead, the optimized features are learned in an automated fashion related to the task under consideration. Tus, robustness to the usual changes of the input data is attained.

3. Generalization: Different data types or different applications can use the same DL technique, an approach frequently referred to as transfer learning (TL) which explained in the latter section. Furthermore, it is a useful approach in problems where data is insufficient.

4. Scalability: DL is highly scalable. ResNet, which was invented by Microsoft, comprises 1202 layers and is frequently applied at a supercomputing scale. Lawrence Livermore National Laboratory (LLNL), a large enterprise working on evolving frameworks for networks, adopted a similar approach, where thousands of nodes can be implemented.

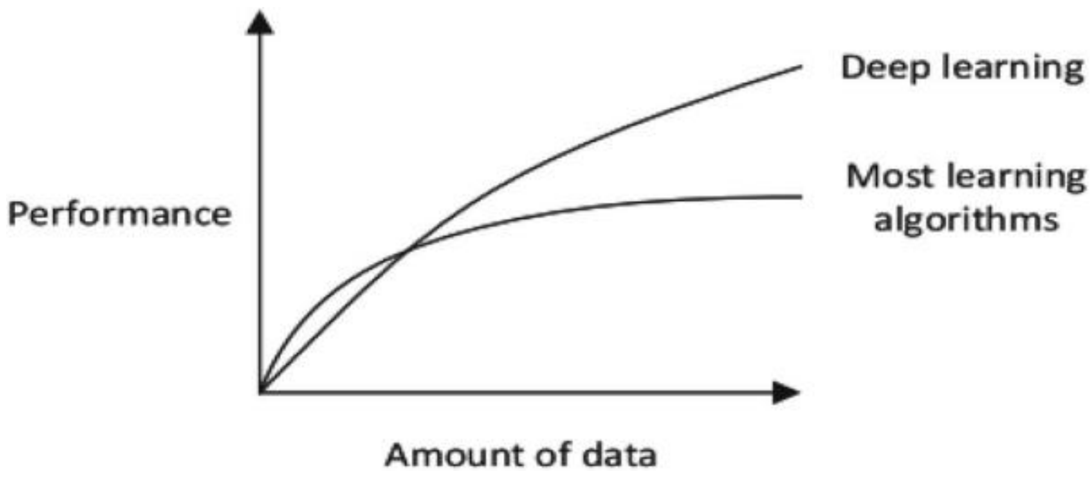


Fig. 3 An illustration of the performance comparison between deep learning (DL) and other machine learning (ML) algorithms, where DL modeling from large amounts of data can increase the performance

Applications

Deep learning implies an abstract layer analysis and hierarchical methods. However, it can be utilized in numerous real-life applications some of them are given below.

- Self-Driving Cars
- Healthcare
- Automatic Game Playing
- Language Translations
- Entertainment
- Visual Recognition
- Automatic Handwriting Generation

But in this paper, we are going to focus on Self-driving cars.

Self-Driving cars

The rapid development of the Internet economy and Artificial Intelligence (AI) has promoted the progress of self-driving cars. The market demand and economic value of self-driving cars are increasingly prominent. At present, more and more enterprises and scientific research institutions have invested in this field. Google, Tesla, Apple, Nissan, Audi, General Motors, BMW, Ford, Honda, Toyota, Mercedes, Nvidia, and Volkswagen have participated in the research and development of self-driving cars.
In this we are going see how Deep learning is utilized to give solution for the self-driving cars

Applications of Deep Learning in the Field of Self-Driving Cars

In this section, the detailed applications based on various deep learning methods will be introduced the main problems that must be addressed in self-driving cars include obstacle detection, traffic signs detection, lane recognition, and so on, which will be introduced in detail as follows.

1.obstacle Detection

Obstacle detection technology is the most fundamental and core technical problem in self-driving systems, which is used to detect the target area that may block the normal driving of the vehicle, and guide the vehicle to avoid obstacles in time through the control system. In recent years, various sensors have been developed and equipped on self-driving cars to realize obstacle detection and recognition, such as the vision sensor, the ultrasonic sensor, the radar sensor, the lidar sensor, and so on. Compared with detection technology based on other sensors, the vision sensor-based detection technology has many advantages, such as fast sampling speed, a large amount of information, and relatively low price. Obstacle detection technology based on vision sensors mainly includes a monocular vision and binocular vision.

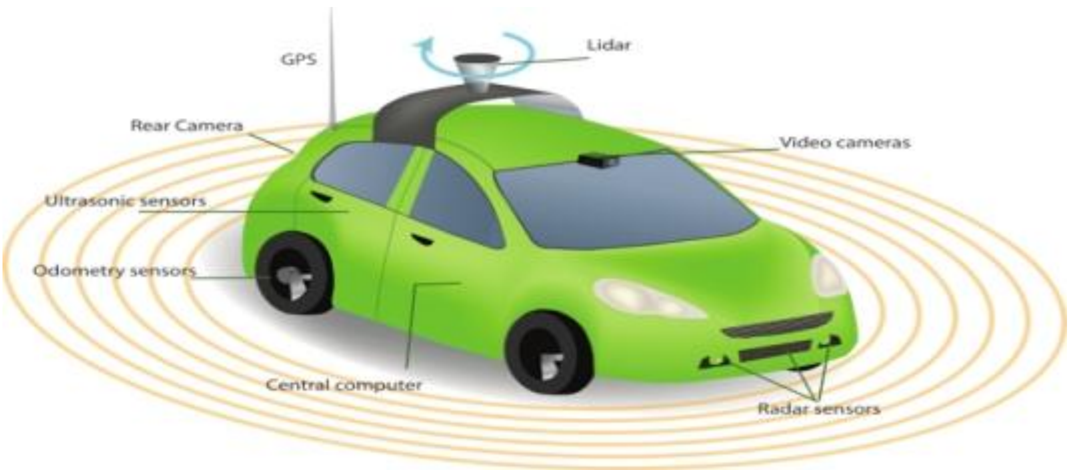


Fig.4 Sensors in Self-driving cars

The binocular vision method is used for this task The advantage of binocular vision over traditional monocular vision is that 3D information of the scene can be directly obtained, and the geometric relationship between obstacles and road surface can be supplemented, so as to serve as the segmentation basis to realize obstacle detection.

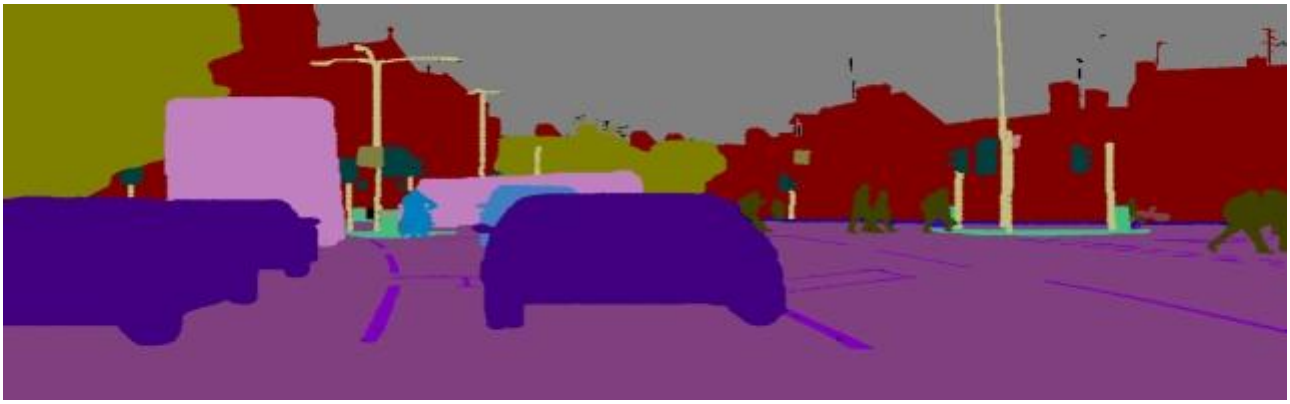


Fig.5.Result of obstacle detection

2. Traffic Signs Detection

Traffic sign detection can be achieved successfully by deep learning. Convolution neural network is the best for processing data. Due to performance issues and in order to make edges between pixels more visible, the depth of the image is changed from three-dimensional to one-dimensional (change their color to gray) for all the images indicated in Fig.6

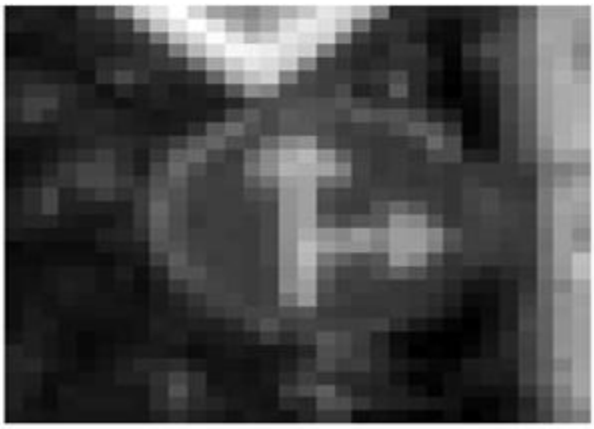


Fig.6 Gray image of a traffic sign

After changing the dimension of the image, for a clearer difference between the edges, we need to equalize the photo as demonstrated in Fig.7. This helps the model find the features, as the model should focus on the edges of the image and differences of the pixels.

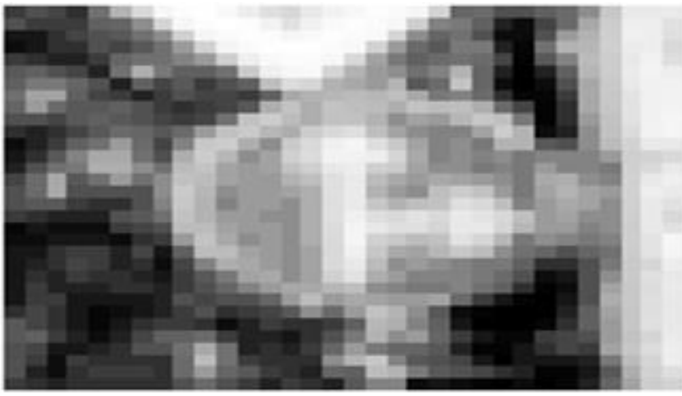


Fig.7 Equalized traffic sign image

The entire dataset is preprocessed in the same way, before starting the training. A very important part diversifies, is data augmentation. Data augmentation is a widely used technique, which helps expand and diversify your training data, providing an added variety of important features, that the network needs to extract. It gives variety to the data and gives more data for the model to work and generalize the new data that can exist. Some of the training data consist of width shift and height shift (zoomed and rotated). This makes the model learn more and train in different data. We have used Kera's for the augmentation of the data. The result is shown in Fig. 8.

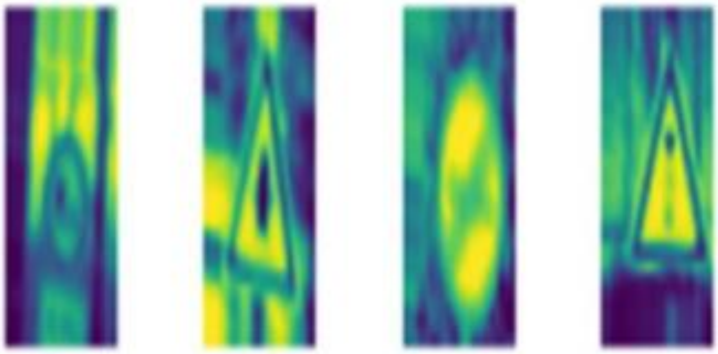


Fig.8 The result of the augmentation process

For the traffic sign, it used the leNet architecture. The input dimensions are 32 pixels width, 32 pixels height, and one depth. LeNet architecture is a convolution neural network structure. Google designed it. It is used in different applications and it is very influential even from the last obtained result. In this model, four convolution layers using the Relu activation function, two MaxPooling layers, and an output layer using the Softmax activation function, as we have a multi-class categorization. Categorical Cross-Entropy is used as a loss function as we need to categorize multiple classes and check for the lowest error. After the data is processed by the model, it is classified into one category as numerical. Each number means a type of traffic sign.

Gradient descent works on reducing the training error and regularization aim to reduce the generalization error.

3. Lane Line Detection

Detecting lane lines in the road is very important for the car to drive. Using the camera in the front of the car can help to detect the lane line. To identify the lines in the road, we can use edge detection and gradient. Edge detection is about sharp changes in intensity in adjacent pixels (a sharp color change). Gradient measures the change in brightness. There is a strong gradient (0 to 255 pixel) and a small gradient (255 to 0 pixel). Five steps are required:

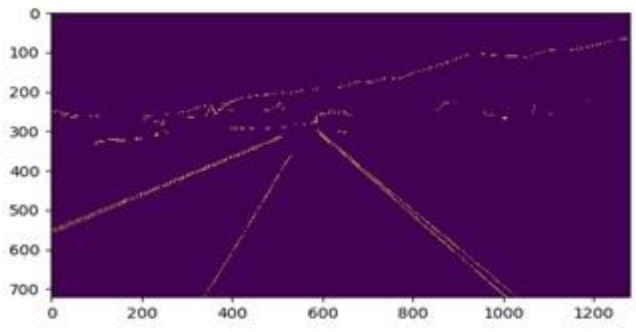
• Step 1: To convert the image to grayscale; so, in one channel. It is processed faster than a normal image with three channels.

• Step 2: To reduce the noise, i.e., converting the colors to be smoothed (blurred).

• Step 3: To determine rapid changes in over image. Derivative f(x,y) measures adjacent changes in all directions x and y. There are high threshold and low thresholds. If the gradient is between the low and high thresholds, it is accepted only if it is connected to a strong edge (the rapid changes in brightness). The rapport between the thresholds is 1/2 or 1/3.

• Step 4: To create a triangle toward the view of the car, because we know that the lane lines are toward the car. Computing the bitwise of both images and taking the bitwise of each homologous pixel in both arrays ultimately makes the image only show the region of interest traced by the polygonal containing the task.

• Step 5: To detect straight lines and mainline. It finds the line which describes the points best.



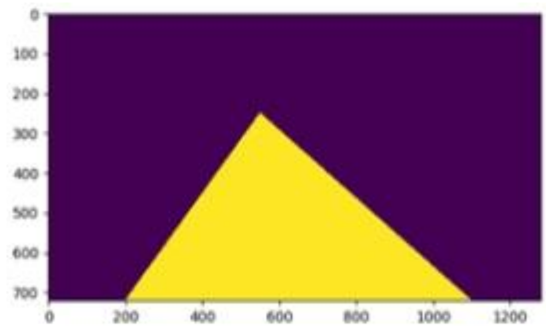


Fig.9 Grayscale image.   Fig .10 Region of interest.

4. Motion Control

Motion control of a vehicle is one of the most fundamental tasks in self-driving cars. Deep learning-based methods are often used as the solutions in the end-to-end control system for self-driving cars, which directly maps sensory data to steering commands. For example, Eraqi, et al. proposed a composite neural network, which is used to estimate the angle of the steering wheel. This network includes a CNN and an LSTM network, which uses the camera as input. The CNN is used to process the camera images frame by frame. The features of the driving scene are extracted by the CNN and then passed into a stack of LSTM layers. The temporal dependence of these features can be learned by the LSTM network. At last, the steering angle prediction is carried out by the output layer. An overview of the block diagram of the system proposed in is shown in Fig 11.

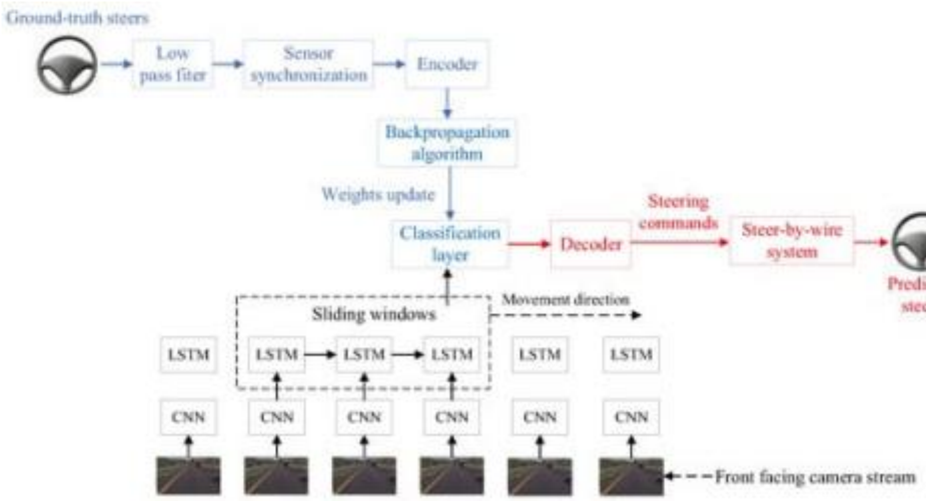


Fig 11. An overview of the block diagram of the system.

During the training process of the method in, the ground-truth steering angle ϕ is encoded as following sine wave function:

$$Yi=\sin(2\pi(i-1)\ N-1-\phi\pi 2\phi max),1\le i\le N,$$

where Yi is the activation of the *i*-th output neuron and *N* is the number of output neurons. In this method, a least squares regression is used in the classification layer, to fit the predicted function. In the process of deployment, the steering angle is output based on the results of the least squares regression.

In addition to the applications mentioned above, there are many other applications of deep learning methods in self-driving cars, such as path planning, Scene Classification and Understanding, pedestrian detection, Steering Angle Detection and so on.

Conclusion

The above study we can conclude that Deep Learning is fast-growing field there are numerus applications based on deep learning. the study shows the features of the deep learning and how it is better than the other algorithms. we can apply deep learning method in different fields and Self-driving car is one of those as given above.

Above study shows that how deep learning providing solutions for evolution of self-driving cars. Self-driving cars are the future of the automobile industry. Lot many companies are working on them. Above study shows that deep learning is applied on different features of self-driving cars like obstacle detection, traffic signs detection, lane recognition, and so on. Self-driving cars in present are not perfect but by applying deep learning by different ways we can make them better for future.

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