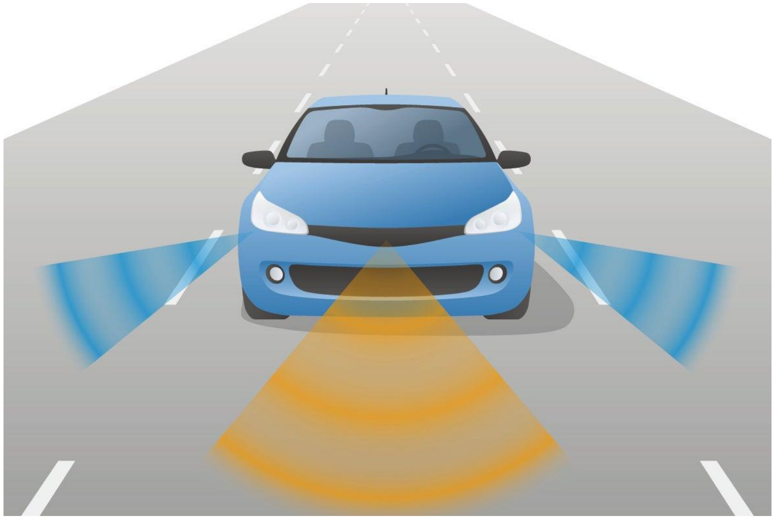
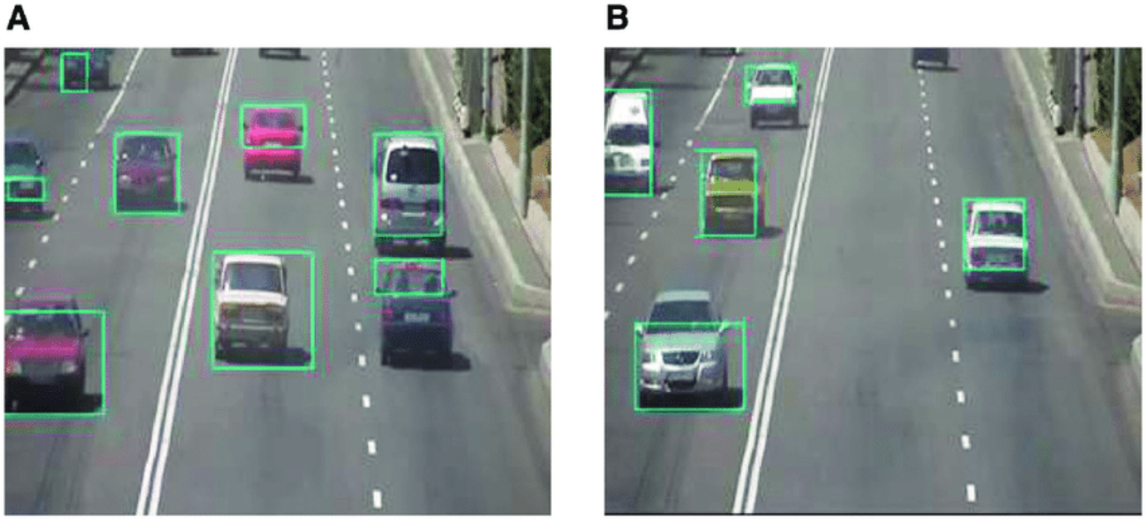
<u>Recurrent neural networks in Autonomous vehicles:</u>

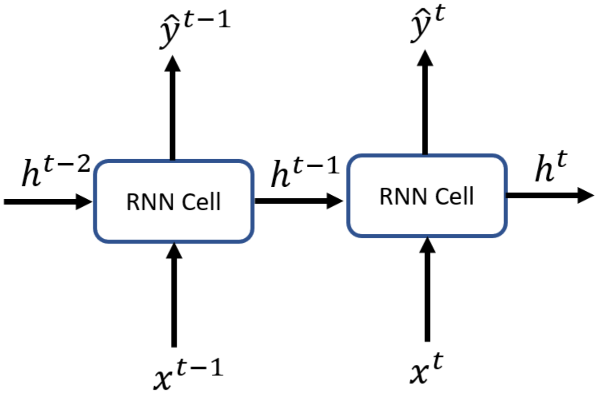
How Recurrent neural networks are used in Autonomous vehicles?Autonomous vehicles see the world through a camera attached in various angles and the camera records what happened in the surroundings. It's basically a video (a sequence of images).Rnn's are known for working well with the sequential data,so we can just feed our images into rnn frame by frame right?,no images have a lot of extra information first we need to use cnn's to extract the information and Feed each of the image in to the recurrent neural network



we use r-cnn,yolo for vehicle detection to get draw bounding boxes around the vehicles(positions of the vehicles).

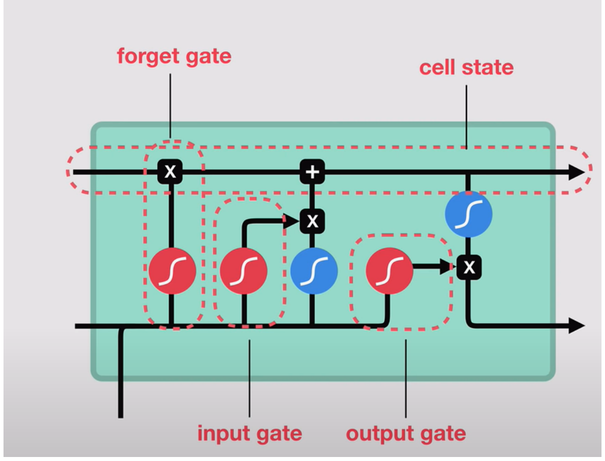


Then we feed the sequence of the images at each time step to the Recurrent neural network and give the output label like what action should we take based on the movement of the vehicles around us,

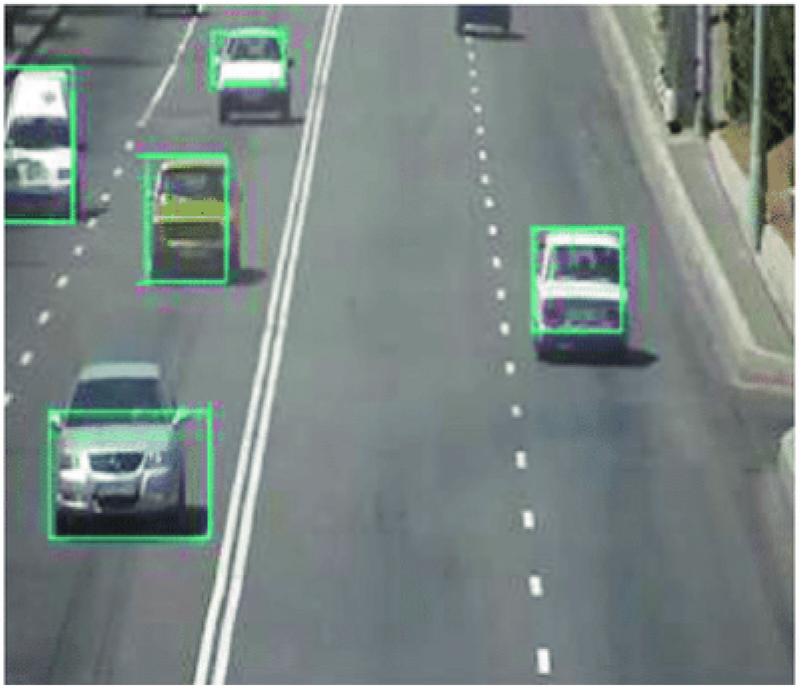


So that’s it right? We give a sequence of images as input and final output is the action we take?,there is a problem here Rnn’s suffer from the vanishing gradient problem if we take a single time step as a second a typical camera records the video in 24 frames per second so in 4-5 seconds we will have 120 images.As the sequence goes on the gradients of the image from the first state becomes irrelevant this is known as vanishing gradient problem.

How do we counter this problem?,Lstm and Gru are introduced as a way of mitigating this problem in Lstm there is a cell state which can theoretically carry the information throughout the Network all the from first step to last step and there are three gates (input,forget and output) gates which regulate the flow of information in the cell state input gate decides what information to add from the previous hidden state and current input,forget gate decides what information to add remove from the previous hidden state and current input(it uses sigmoid activation 0-1 more the number close to 0 more is the probability to remove it) and we combine both of them to update the cell state and output gate decides what information to pass on from this state(hidden state of current step) and gru works kind of similar but with 2 gates update and reset gate these are computationally less expensive as these only have to update two gates.



How do these gates help us in mitigating the vanishing gradient problem?,these gates can help us to remember only the important information,**in self driving cars** only some of the cars are important in predicting the path we should approach like the cars in other lane or the cars far away don't matter to us,only the cars in front of us or the cars taking turns which may interfere in our direction matter to us,these are only possible by using gates in lstm and gru which is not possible with vanilla rnn.



In the above image if we are in the right lane the cars only in the front of us are useful in making decisions on where to go the cars in the right won't matter unless we take a turn or they are heading towards in our direction if we are they are heading in the opposite direction they can be forgotten