**FIT3081 IMAGE PROCESSING – ASSIGNMENT 1**

**CAR NUMBER PLATE DETECTION ALGORITHM**

**ASSIGNMENT GROUP NUMBER – 09**

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**Introduction**

The problem being solved in this assignment is to identify the position of the car plate, crop out the part of the car plate, and extract and show the characters on the car plate on small segments. My team have attempted multiple approaches to this problem. The first approach was based on our intuition that a car plate is a rectangle plane with 4 edges and the edges meet at the corners. So, we tried to crop the car plate by finding the car plate using Hough Transform and Corner algorithms but we realized that a vehicle can have more lines that are stronger than the edges on the car plate, for example, the lines on the grill on the front of the cars and the outlines of the car. Our second attempt was to generalize the position of the car by assuming that it is around a certain position and use edge detection algorithms to detect the car plate. After both attempts, we figured out a way to extract the car plate, but even with this solution, we realised that a few conditions need to be met so that the car number plate can be detected accurately. The tasks that our algorithm must undertake are the pre-processing of an input image containing a car in order to retrieve the component of the image containing the number plate, perform further processing so that the characters that are present inside the plate can be extracted and finally separate each character into its own segment.

**Assumptions :**

1. The car number plate is positioned towards the centre of the image.
2. The image only contains a single car number plate, and that there are minimal to no other objects around the car.

**Overall Methodology**

**Diagram

Description automatically generated**

**Short Description**

***Pre-processing***

During pre-processing, the algorithm first resizes and crops the input image based on its predetermined boundaries. It will then generate all the corner points by using the Harris Corner Detection Algorithm which is heavily inspired by the contents in week 5, from the resulting image before selecting the 25 strongest corner points and remove any outliers in this list of corners points. The assumption here is that the car plate will be the only object with a high frequency of corners in the image. After detecting the corners of the car plate, we crop out the car plate using the minimum and maximum x, y coordinates.

***Image Skeletonization***

After cropping out the car number plate, we then generate the skeleton for the car plate and remove any unwanted branches by pruning the image.

***Example***

**A picture containing diagram

Description automatically generatedA picture containing shape

Description automatically generatedA picture containing text, sign, plate, dishware

Description automatically generated**

Skeleton Pruned

***Splitting Rows***

If the pruned image has a width to height ratio that is similar to the width to height ratio of a double row car plate, then split the row using image dilation. The idea of dilation is to use a rectangle structural element with high width to height ratio so that the characters on the same row can merged together into a single white strip and so the two rows can be separated by a thin black line, then we loop through the rows to find the black line and use the black line to crop out the upper and lower row. After splitting, the rows are then recombined into a single row.

***Example***

**![Text

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4SoERXhpZgAATU0AKgAAAAgABgALAAIAAAAmAAAIYgESAAMAAAABAAEAAAExAAIAAAAmAAAIiAEyAAIAAAAUAAAIrodpAAQAAAABAAAIwuocAAcAAAgMAAAAVgAAEUYc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFdpbmRvd3MgUGhvdG8gRWRpdG9yIDEwLjAuMTAwMTEuMTYzODQAV2luZG93cyBQaG90byBFZGl0b3IgMTAuMC4xMDAxMS4xNjM4NAAyMDIxOjA0OjE0IDExOjQ5OjQ3AAAGkAMAAgAAABQAABEckAQAAgAAABQAABEwkpEAAgAAAAM5NQAAkpIAAgAAAAM5NQAAoAEAAwAAAAEAAQAA6hwABwAACAwAAAkQAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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48L3JkZjpSREY+PC94OnhtcG1ldGE+DQogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgCiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAKICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIAogICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIC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rectangle

Description automatically generated

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confidence](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4SDcRXhpZgAATU0AKgAAAAgABgALAAIAAAAmAAAIYgESAAMAAAABAAEAAAExAAIAAAAmAAAIiAEyAAIAAAAUAAAIrodpAAQAAAABAAAIwuocAAcAAAgMAAAAVgAAEUYc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFdpbmRvd3MgUGhvdG8gRWRpdG9yIDEwLjAuMTAwMTEuMTYzODQAV2luZG93cyBQaG90byBFZGl0b3IgMTAuMC4xMDAxMS4xNjM4NAAyMDIxOjA0OjE0IDExOjUxOjQ3AAAGkAMAAgAAABQAABEckAQAAgAAABQAABEwkpEAAgAAAAMxNAAAkpIAAgAAAAMxNAAAoAEAAwAAAAEAAQAA6hwABwAACAwAAAkQAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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YtV8RPeeIvBst8lpY29zdWsF5bSiC3itYpplEkb2yFYUkfb9oK7mADbRuzvj34t034e6dffBPwRd/bPC+j6k0uq64Cqy67fKoUs/lsUMELB1iUlurvuy+1fBNxoA91H7J194gu1svA3xB8DfELVG2gaXo2qvb3cjNu2rFFdxwmdjsPEW8rwWCggnyPxd4P1rwF4iv8AQPEek3mh63YOI7mwv4WimiYgMMqwBGVIYHoQQRkEVj7j619Lab4qu/jz+yr4s0bXpl1LxX8OpLPV9I1CSBDdy6S5+zXFs8+3c0cLNC6qzE/OQPlQAAH6x/8ABLv/AJMp8B/715/6VS19XV8o/wDBLv8A5Mp8B/715/6VS19XUAFFFFABRRRQAx/uN9DX8vfxE/5KB4m/7Cd1/wCjWr+oR/uN9DX8vfxE/wCSgeJv+wndf+jWoAxLX/j6h/31/nXuv7dGP+GpvG3/AG4/+kNvXgyMVZWU/MDkcV9C/tteHJNL+JfhvWZIbrz/ABH4U0jV7u8uS7C6upLVBM6k8ABht2JhUwFAAGKAPnijcaKKADNFFFABXuPgaU6X+yL8VLu2/d3OoeIdD0q5frvttl3ceXg8D97bwtuGG+XGcEg+HV7d4W/5M3+IX/Y46H/6S6jQB4jk16D8DfiWfhZ8RNP1S4ElxoVwfsWtaePmjvrB2UzQyJkCRSFVtjHBKLnHWvPqXcfWgD039or4Lv8AAr4rap4ZivW1jRCqXuja2qr5WqWEqhobiJlJV0YZG5CQSp+leY19EfDOO6/aM+EMvwta5EnjPwubjW/CQmDSPe23llr3TEIyd5WNZ4lAxmOVergj552igBtFFa/hTwnq/jnxJpvh/QNOn1bWtSnW3tLK2XdJLIxwFH+J4A5OKAPcPiEz/D/9kX4UaZpVzdQL46l1TW9bMcuyO6EF2LW2gkUffWI2zyKWJw074FfPFfUvxl8WfD3wTb+CvhTrWl6n8QIvAcU9pfatZ6nHp2yeeTzrmztmSOVJIopjIRK4LMzOPuKlcR/wmf7P3/RLPG3/AIWsH/yuoA8Rr6Y+I+sS/ED9g/4QXNvAlrb/AA78R6v4bvDNLl7qTUcX8MkagYCqsEyMGOQQhGQxC8r/AMJn+z9/0Szxt/4WsH/yurtvi7eWfxb/AGcfClz8MNP1DSvBfgCOVPEnhy4eOZ7K7nuFEOoSXKqj3JuN7gbkxD5Dqu1XAYA+W6KKKACjJoooAfnpX1J8Ztft/CP7FXwi+Gmpb4/Fc2oz+MPs6FXWLT7mMi2dyDlXkDbwpGduGOAy5b8B/gr8PvAfxC8La78W/iT4TtrWOWK7i8N2M7ao00xG6FLySFWhhgD7TJ8zttDLtGdw8N+Ll5r958RdaHiXWINc1W3m+zNeWeoJfW5RAFjWGVGZTEqBVUKcKABgYwADjKKKKACnbQelaHh/w7qPirWrHR9HsptR1S+mWC2tbdC8ksjHAUAd6+mv2f8A9m/w74H+KXhPV/j/AK54e8IeFo5jc3vhfWbyQapOioxjV7aKN2jUv5TFZjHuRuM5oA4jwv8ADnwz8JfCNh46+I0sOpazeIlzoHgCNgZbtSFeO61Aht0FqQQypjfMMY2qS9eY/ED4j+IPifrg1bxFqDXtxFClrbxqixQWsCDEcMMSAJFGo4CIAB6V6R+0F8LfiBHd3HxB1zVdJ8caLqUyxf8ACTeF7tLrT0cpuS3KoFNttjHywvHHtUABQBivEaAE3H1oqTyW8sPtO0nbnHGfSo6ACveP23f+TidR/wCwD4d/9MdjXj/hLwzc+M/FWjeH7Joor3Vb2GwgaYkRiSV1RSxAJAywyQDx2r0z9rzxBB4j/aG8VvbxyJFpos9CLSYBkaws4bJ5MAnAdrcsBnIDAUAeN17/APsga5feDtb+JHizR5/sniDw/wCC7++0272q/kTGSCEvsYFX+SWQYYEfNnqBXgFe0fsm/FLw38J/jBbX/jSzk1PwdqVlc6Vq9rHEsyyQzRkKXjYgOiyCNyvX5cjJABAPF9xorsvir8LdW+EPjCbw9rL280whhure6s5PMhuYJY1kilRuOGVhwQCDkEZGK42gAr6J/Y3isb7VPibYa/PJY+ELrwXfrrGoQjMlsilHhKjnlp1hTochj06j542g19CfDm1h+F37LvxF8W6lKkGreNvI8L6BYySDfPbLKJr+5MfB2KYoY1kBxvZwRxQB+un/AAS7/wCTKfAf+9ef+lUtfV1fKP8AwS7/AOTKfAf+9ef+lUtfV1ABRRRQAUUUUAMf7jfQ1/L38RP+SgeJv+wndf8Ao1q/qGIB4r5e1H/gmR+zVq2oXN9d/Dbzbq5laaWT+3dTG52JLHAucDJJ6UAfz9KxU5BxWvr3jLX/ABTHBHrOt6hq0cEks0S3108wjeQgyMoYnBYqpJHXAzX7zf8ADrj9mL/omf8A5X9U/wDkmj/h1x+zF/0TP/yv6p/8k0AfgDRX7/f8OuP2Yv8Aomf/AJX9U/8Akmj/AIdcfsxf9Ez/APK/qn/yTQB+ANFfv9/w64/Zi/6Jn/5X9U/+SaP+HXH7MX/RM/8Ayv6p/wDJNAH4A16r4V+KPhzSfgL4s+H+paBqV3qetanb6rb6tb6ikUVrJbxyJErQGFjIGE82794vRMdDn9qf+HXH7MX/AETP/wAr+qf/ACTR/wAOuf2Yv+iZ/wDlf1P/AOSaAPwBor9/v+HXH7MX/RM//K/qn/yTR/w64/Zi/wCiZ/8Alf1T/wCSaAPwc8HX8Gk+KtKu7jU77RoIbhHk1DTIvMuYFB+Zo08yPc2Og3rn1FeofHrx98Lvi5rOv+L/AAz4c1f4fa/eXnnf8I+kkF7p1wHbLyLIqwtbEZ/1YjkB/vLX7Kf8Ouv2Y/8Aomf/AJX9T/8Akmk/4dc/sx/9Ez/8r+qf/JNAH4A1718PfFPw2+GXwj8V3EOuanf/ABV13TIoNNuLXR1EGhEXOZkW4ecN5skSKpljjBjDkKzBnr9hP+HXH7MX/RM//K/qn/yTR/w65/Zi/wCiZ/8Alf1T/wCSaAPwBzRX7/f8OuP2Yv8Aomf/AJX9U/8Akmj/AIdcfsxf9Ez/APK/qn/yTQB+ANex/sw+JvDWh+M9a0zxtqI0vwR4h0abStbuIwxuRB50M6C32q37zz7eAnII2B++K/Zv/h1x+zF/0TP/AMr+qf8AyTS/8Ouv2Y/+iZ/+V/U//kmgD8DdW09NM1O7tI7u3v44JmiW7tSximCsQHQsAdpxkZAODyB0qlX7/wD/AA66/Zj/AOiZ/wDlf1T/AOSaT/h1x+zF/wBEz/8AK/qn/wAk0AfgDRX7/f8ADrj9mL/omf8A5X9U/wDkmj/h1x+zF/0TP/yv6p/8k0AfgDuJo3Gv3+/4dcfsxf8ARM//ACv6p/8AJNH/AA64/Zi/6Jn/AOV/VP8A5JoA/AGiv3+/4dcfsxf9Ez/8r+qf/JNH/Drj9mL/AKJn/wCV/VP/AJJoA/EDwf8AGzxX4B8D6z4Y8PXNppVnrLsb+9hsYTfSoVVfKFyymSOPAb5Y2XPmOGyGxXBPI8jFnYsx6ljmv38/4dc/sx/9Ez/8r+qf/JNH/Drj9mL/AKJn/wCV/VP/AJJoA/C34b/Fjxb8I9c/tbwjrlxo14yeXKqBZIbiPIPlzQuGjlTIB2OrLkA44r1j/hvj41/9DBof/hHaL/8AIdfr1/w64/Zi/wCiZ/8Alf1T/wCSaP8Ah1x+zF/0TP8A8r+qf/JNAH4t/GD9pLxV8cvDfh/TvFcOmS3mkTXEq6hp9jHYtcCUIAJYYFSElRHgOEDYOCTivJa/f7/h1z+zH/0TP/yvan/8k0f8OuP2Yv8Aomf/AJX9U/8AkmgD8I/h74mXwV488N+Intzdx6RqVtftbqwUyCKVX257Z24zW18dNb0jxR8YPF+t6DfNqOj6rqMuoW08kJhcLMfM2Mh6MhcocEglSQSCCf3D/wCHXX7Mf/RM/wDyv6p/8k0D/gl1+zGDn/hWf/lf1P8A+SaAPwAoya/f7/h1x+zF/wBEz/8AK/qn/wAk0f8ADrj9mL/omf8A5X9U/wDkmgD8W/h58YdIt/Cq+C/iHoM/izwZHN9os/sdytvqOlynO4205RgI3zloWBUkBhtbJPQRfC34Fao0t1F8a9R0a1kkYwWV/wCE5p7mOPPyiV45QhfHXZkD1NfsJ/w65/Zj/wCiZ/8Alf1T/wCSaP8Ah1z+zH/0TP8A8r+qf/JNAH5E2q/s/fCVodRjv9c+M2uRMZILGay/sfSA38BuAzPLKAwBMa7Q4YDcOa80+LXxq8V/GnVLG78S3lu8WmwG10+wsLKGztbGDcWEUUUSKoAJ6kFjgZJr9wf+HXP7Mf8A0TP/AMr+qf8AyTR/w65/Zi/6Jn/5XtT/APkmgCP/AIJd/wDJlPgP/evP/SqWvq6uT+F3wr8L/BfwTYeEfBul/wBj+HrEubez+0Sz7N7F2+eVmc5ZieSetdZQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAf/2Q==)**

***Splitting Columns***

At this stage, we will have a skeletonized, pruned and binarized car plate that only have a single row of characters. We use dilation with an SE with a high height to width ratio so that each character will dilate until only a white column is left with black lines separating each column. Here each column represents a character. By looping through the column, we can obtain the boundaries and crop out each character into individual segments.

***Example***

Shape, arrow

Description automatically generated**![Text

Description automatically generated with medium confidence](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4SDcRXhpZgAATU0AKgAAAAgABgALAAIAAAAmAAAIYgESAAMAAAABAAEAAAExAAIAAAAmAAAIiAEyAAIAAAAUAAAIrodpAAQAAAABAAAIwuocAAcAAAgMAAAAVgAAEUYc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFdpbmRvd3MgUGhvdG8gRWRpdG9yIDEwLjAuMTAwMTEuMTYzODQAV2luZG93cyBQaG90byBFZGl0b3IgMTAuMC4xMDAxMS4xNjM4NAAyMDIxOjA0OjE0IDExOjUxOjQ3AAAGkAMAAgAAABQAABEckAQAAgAAABQAABEwkpEAAgAAAAMxNAAAkpIAAgAAAAMxNAAAoAEAAwAAAAEAAQAA6hwABwAACAwAAAkQAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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YtV8RPeeIvBst8lpY29zdWsF5bSiC3itYpplEkb2yFYUkfb9oK7mADbRuzvj34t034e6dffBPwRd/bPC+j6k0uq64Cqy67fKoUs/lsUMELB1iUlurvuy+1fBNxoA91H7J194gu1svA3xB8DfELVG2gaXo2qvb3cjNu2rFFdxwmdjsPEW8rwWCggnyPxd4P1rwF4iv8AQPEek3mh63YOI7mwv4WimiYgMMqwBGVIYHoQQRkEVj7j619Lab4qu/jz+yr4s0bXpl1LxX8OpLPV9I1CSBDdy6S5+zXFs8+3c0cLNC6qzE/OQPlQAAH6x/8ABLv/AJMp8B/715/6VS19XV8o/wDBLv8A5Mp8B/715/6VS19XUAFFFFABRRRQAx/uN9DX8vfxE/5KB4m/7Cd1/wCjWr+oR/uN9DX8vfxE/wCSgeJv+wndf+jWoAxLX/j6h/31/nXuv7dGP+GpvG3/AG4/+kNvXgyMVZWU/MDkcV9C/tteHJNL+JfhvWZIbrz/ABH4U0jV7u8uS7C6upLVBM6k8ABht2JhUwFAAGKAPnijcaKKADNFFFABXuPgaU6X+yL8VLu2/d3OoeIdD0q5frvttl3ceXg8D97bwtuGG+XGcEg+HV7d4W/5M3+IX/Y46H/6S6jQB4jk16D8DfiWfhZ8RNP1S4ElxoVwfsWtaePmjvrB2UzQyJkCRSFVtjHBKLnHWvPqXcfWgD039or4Lv8AAr4rap4ZivW1jRCqXuja2qr5WqWEqhobiJlJV0YZG5CQSp+leY19EfDOO6/aM+EMvwta5EnjPwubjW/CQmDSPe23llr3TEIyd5WNZ4lAxmOVergj552igBtFFa/hTwnq/jnxJpvh/QNOn1bWtSnW3tLK2XdJLIxwFH+J4A5OKAPcPiEz/D/9kX4UaZpVzdQL46l1TW9bMcuyO6EF2LW2gkUffWI2zyKWJw074FfPFfUvxl8WfD3wTb+CvhTrWl6n8QIvAcU9pfatZ6nHp2yeeTzrmztmSOVJIopjIRK4LMzOPuKlcR/wmf7P3/RLPG3/AIWsH/yuoA8Rr6Y+I+sS/ED9g/4QXNvAlrb/AA78R6v4bvDNLl7qTUcX8MkagYCqsEyMGOQQhGQxC8r/AMJn+z9/0Szxt/4WsH/yurtvi7eWfxb/AGcfClz8MNP1DSvBfgCOVPEnhy4eOZ7K7nuFEOoSXKqj3JuN7gbkxD5Dqu1XAYA+W6KKKACjJoooAfnpX1J8Ztft/CP7FXwi+Gmpb4/Fc2oz+MPs6FXWLT7mMi2dyDlXkDbwpGduGOAy5b8B/gr8PvAfxC8La78W/iT4TtrWOWK7i8N2M7ao00xG6FLySFWhhgD7TJ8zttDLtGdw8N+Ll5r958RdaHiXWINc1W3m+zNeWeoJfW5RAFjWGVGZTEqBVUKcKABgYwADjKKKKACnbQelaHh/w7qPirWrHR9HsptR1S+mWC2tbdC8ksjHAUAd6+mv2f8A9m/w74H+KXhPV/j/AK54e8IeFo5jc3vhfWbyQapOioxjV7aKN2jUv5TFZjHuRuM5oA4jwv8ADnwz8JfCNh46+I0sOpazeIlzoHgCNgZbtSFeO61Aht0FqQQypjfMMY2qS9eY/ED4j+IPifrg1bxFqDXtxFClrbxqixQWsCDEcMMSAJFGo4CIAB6V6R+0F8LfiBHd3HxB1zVdJ8caLqUyxf8ACTeF7tLrT0cpuS3KoFNttjHywvHHtUABQBivEaAE3H1oqTyW8sPtO0nbnHGfSo6ACveP23f+TidR/wCwD4d/9MdjXj/hLwzc+M/FWjeH7Joor3Vb2GwgaYkRiSV1RSxAJAywyQDx2r0z9rzxBB4j/aG8VvbxyJFpos9CLSYBkaws4bJ5MAnAdrcsBnIDAUAeN17/APsga5feDtb+JHizR5/sniDw/wCC7++0272q/kTGSCEvsYFX+SWQYYEfNnqBXgFe0fsm/FLw38J/jBbX/jSzk1PwdqVlc6Vq9rHEsyyQzRkKXjYgOiyCNyvX5cjJABAPF9xorsvir8LdW+EPjCbw9rL280whhure6s5PMhuYJY1kilRuOGVhwQCDkEZGK42gAr6J/Y3isb7VPibYa/PJY+ELrwXfrrGoQjMlsilHhKjnlp1hTochj06j542g19CfDm1h+F37LvxF8W6lKkGreNvI8L6BYySDfPbLKJr+5MfB2KYoY1kBxvZwRxQB+un/AAS7/wCTKfAf+9ef+lUtfV1fKP8AwS7/AOTKfAf+9ef+lUtfV1ABRRRQAUUUUAMf7jfQ1/L38RP+SgeJv+wndf8Ao1q/qGIB4r5e1H/gmR+zVq2oXN9d/Dbzbq5laaWT+3dTG52JLHAucDJJ6UAfz9KxU5BxWvr3jLX/ABTHBHrOt6hq0cEks0S3108wjeQgyMoYnBYqpJHXAzX7zf8ADrj9mL/omf8A5X9U/wDkmj/h1x+zF/0TP/yv6p/8k0AfgDRX7/f8OuP2Yv8Aomf/AJX9U/8Akmj/AIdcfsxf9Ez/APK/qn/yTQB+ANFfv9/w64/Zi/6Jn/5X9U/+SaP+HXH7MX/RM/8Ayv6p/wDJNAH4A16r4V+KPhzSfgL4s+H+paBqV3qetanb6rb6tb6ikUVrJbxyJErQGFjIGE82794vRMdDn9qf+HXH7MX/AETP/wAr+qf/ACTR/wAOuf2Yv+iZ/wDlf1P/AOSaAPwBor9/v+HXH7MX/RM//K/qn/yTR/w64/Zi/wCiZ/8Alf1T/wCSaAPwc8HX8Gk+KtKu7jU77RoIbhHk1DTIvMuYFB+Zo08yPc2Og3rn1FeofHrx98Lvi5rOv+L/AAz4c1f4fa/eXnnf8I+kkF7p1wHbLyLIqwtbEZ/1YjkB/vLX7Kf8Ouv2Y/8Aomf/AJX9T/8Akmk/4dc/sx/9Ez/8r+qf/JNAH4A1718PfFPw2+GXwj8V3EOuanf/ABV13TIoNNuLXR1EGhEXOZkW4ecN5skSKpljjBjDkKzBnr9hP+HXH7MX/RM//K/qn/yTR/w65/Zi/wCiZ/8Alf1T/wCSaAPwBzRX7/f8OuP2Yv8Aomf/AJX9U/8Akmj/AIdcfsxf9Ez/APK/qn/yTQB+ANex/sw+JvDWh+M9a0zxtqI0vwR4h0abStbuIwxuRB50M6C32q37zz7eAnII2B++K/Zv/h1x+zF/0TP/AMr+qf8AyTS/8Ouv2Y/+iZ/+V/U//kmgD8DdW09NM1O7tI7u3v44JmiW7tSximCsQHQsAdpxkZAODyB0qlX7/wD/AA66/Zj/AOiZ/wDlf1T/AOSaT/h1x+zF/wBEz/8AK/qn/wAk0AfgDRX7/f8ADrj9mL/omf8A5X9U/wDkmj/h1x+zF/0TP/yv6p/8k0AfgDuJo3Gv3+/4dcfsxf8ARM//ACv6p/8AJNH/AA64/Zi/6Jn/AOV/VP8A5JoA/AGiv3+/4dcfsxf9Ez/8r+qf/JNH/Drj9mL/AKJn/wCV/VP/AJJoA/EDwf8AGzxX4B8D6z4Y8PXNppVnrLsb+9hsYTfSoVVfKFyymSOPAb5Y2XPmOGyGxXBPI8jFnYsx6ljmv38/4dc/sx/9Ez/8r+qf/JNH/Drj9mL/AKJn/wCV/VP/AJJoA/C34b/Fjxb8I9c/tbwjrlxo14yeXKqBZIbiPIPlzQuGjlTIB2OrLkA44r1j/hvj41/9DBof/hHaL/8AIdfr1/w64/Zi/wCiZ/8Alf1T/wCSaP8Ah1x+zF/0TP8A8r+qf/JNAH4t/GD9pLxV8cvDfh/TvFcOmS3mkTXEq6hp9jHYtcCUIAJYYFSElRHgOEDYOCTivJa/f7/h1z+zH/0TP/yvan/8k0f8OuP2Yv8Aomf/AJX9U/8AkmgD8I/h74mXwV488N+Intzdx6RqVtftbqwUyCKVX257Z24zW18dNb0jxR8YPF+t6DfNqOj6rqMuoW08kJhcLMfM2Mh6MhcocEglSQSCCf3D/wCHXX7Mf/RM/wDyv6p/8k0D/gl1+zGDn/hWf/lf1P8A+SaAPwAoya/f7/h1x+zF/wBEz/8AK/qn/wAk0f8ADrj9mL/omf8A5X9U/wDkmgD8W/h58YdIt/Cq+C/iHoM/izwZHN9os/sdytvqOlynO4205RgI3zloWBUkBhtbJPQRfC34Fao0t1F8a9R0a1kkYwWV/wCE5p7mOPPyiV45QhfHXZkD1NfsJ/w65/Zj/wCiZ/8Alf1T/wCSaP8Ah1z+zH/0TP8A8r+qf/JNAH5E2q/s/fCVodRjv9c+M2uRMZILGay/sfSA38BuAzPLKAwBMa7Q4YDcOa80+LXxq8V/GnVLG78S3lu8WmwG10+wsLKGztbGDcWEUUUSKoAJ6kFjgZJr9wf+HXP7Mf8A0TP/AMr+qf8AyTR/w65/Zi/6Jn/5XtT/APkmgCP/AIJd/wDJlPgP/evP/SqWvq6uT+F3wr8L/BfwTYeEfBul/wBj+HrEubez+0Sz7N7F2+eVmc5ZieSetdZQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAf/2Q==)**A picture containing text, chain

Description automatically generated

**Detailed Description**

***Pre-processing***

I = rgb2gray(imresize(imread("Plate1.jpg"), [512,512]));

I\_cropped\_1 = imcrop(I, [103 103 307 307]);

corners = detectHarrisFeatures(I\_cropped\_1).selectStrongest(25);

TF = rmoutliers(corners.Location,'median');

X = min(TF(:,1));

Y = min(TF(:,2));

h = max(TF(:,2)) - Y;

w = max(TF(:,1)) - X;

I\_cropped\_2 = imcrop(I\_cropped\_1, [X-10 Y-5 w+20 h+10]);

figure,

subplot(1,3,1); imshow(I); title("Original Image");

subplot(1,3,2); imshow(I\_cropped\_1); title("First round cropping");

subplot(1,3,3); imshow(I\_cropped\_2); title("Second round cropping");

The first step is to resize the image into a standard size (512 x 512), then use the rgb2gray function to convert the image into a grayscale image. The second step is to crop out the centre part of the image because we assume that the car plate is around the centre. The crop rectangle used in the *imcrop* function for this step uses values that represent a crop that will produce the centre 60% of the image. The third step is to use the Harris detection algorithm, *detectHarrisFeatures*, a corner detection algorithm introduced by Chris Harris and Mike Stephens, to extract the 25 strongest corner points. The corners will mainly reside on the car plate due to the sharp contrast of the white coloured letters on black plate. Subsequently, use *rmoutliers* to remove corners that are not around the car plate based on the median value of the given corner points. The fourth step is to use these corner points to find the minimum x, y, the appropriate width and height to crop, before applying *imcrop* again to extract the car plate with these values.

***Image skeletonization***

I\_after = imbinarize(I\_cropped\_2);

skel = bwmorph(I\_after,'skel', Inf);

prunned = bwmorph(skel, “spur”, 3);

figure,

subplot(1,3,1); imshow(I\_after); title("Binary Image");

subplot(1,3,2); imshow(skel); title("Image Skeleton");

subplot(1,3,3); imshow(prunned); title("Prunned Image Skeleton");

The first step is producing a binary image from the cropped image using the *imbinarize* function. The second step is to skeletonize it so we can have a single-pixel thick skeleton of the car plate number. We also performed pruning on the skeletonized image so that unwanted branches from the skeleton are removed.

***Splitting Rows***

% If got two rows then split it in half and join it back with the first row

[w, h] = size(prunned);

d = h-w;

if d <= 25

[character\_head, character\_width] = getLump(prunned, 1);

Image = [];

for i = 1:length(character\_head)

[k, w] = size(prunned);

X = 0;

Y = character\_head(i);

h = character\_width(i);

im = imcrop(prunned, [X Y w h]);

im = imresize(im, [500 1200]);

Image = [Image {im}];

%subplot(1,length(character\_head) ,i ), imshow(mat2gray(im));

end

a = montage(Image, 'Size', [1 2]);

a = a.CData;

a = imbinarize(a);

prunned = bwmorph(a, 'thicken');

end

The first step of splitting the row is to check the difference between the height and the width, if the difference is less or equal to 25, the number 25 is an arbitrary number set to fit the data set. If the detected car plate is indeed two rows, then use the *getLump* function to get the separate rows, then use montage to recombine those rows.

***Splitting Columns***

[character\_head, character\_width] = getLump(prunned, 0);

for i = 1:length(character\_head)

[h, z] = size(prunned);

X = character\_head(i);

Y = 0;

w = character\_width(i);

im = imcrop(prunned, [X-2 Y w+2 h]);

im = imresize(im, [1200 500]);

subplot(1, length(character\_head), i), imshow(mat2gray(im));

end

Use *getLump* again to dilate the car plate with an SE and extract the separate character on the car plate. The rest of the function will loop through each character and print it out in separate subplots.

**getLump(image, dir)**

image is a binarized, skeletonized and pruned image

dir is the direction you want to dilate, if you want to dilate it to get row, then dir = 1

if you want to dilate to get column, then dir = 0

Basically, it will dilate the image with the pre-set SE for each dir, then depending if it is row or column, it will loop through the dilated image to find the boundaries, if a boundary is found it will store it in the character\_head and character\_width and returned it.

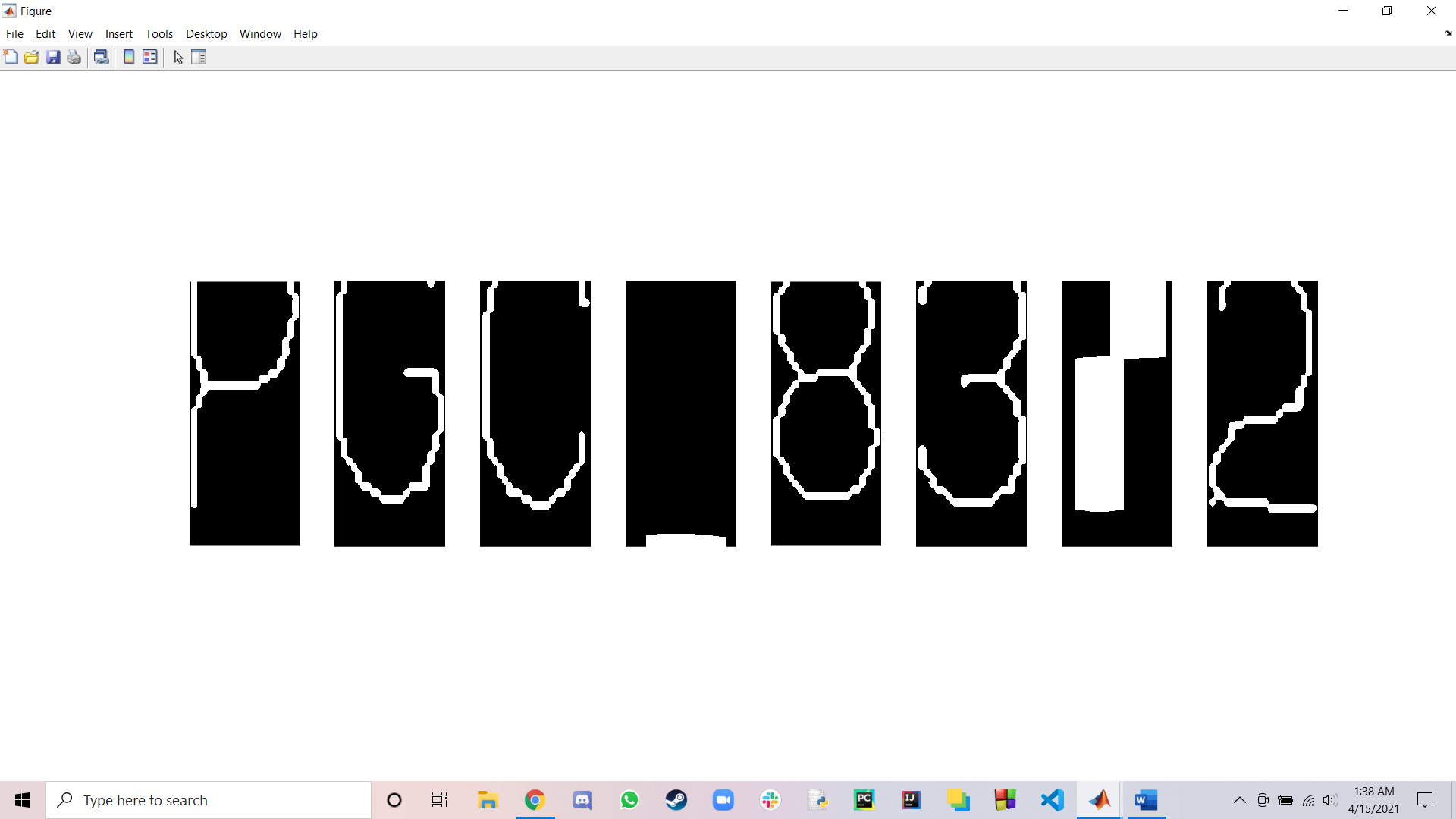
**Results**

***Image 1 (“Plate1.jpg”)***

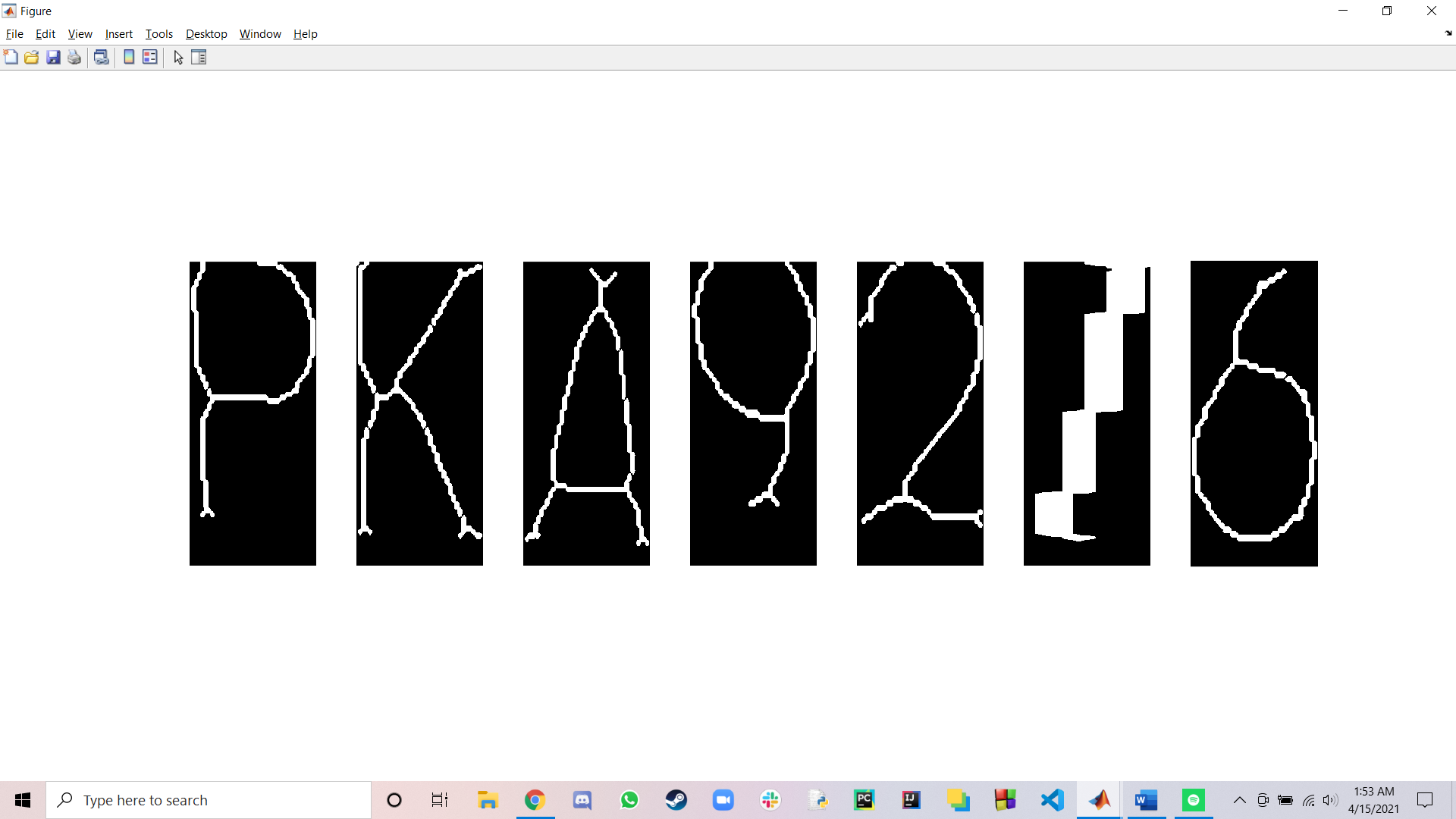
This is a standard image of a car with its number plate positioned clearly and centrally in the image with good lighting and no other objects in and around the car itself. It can be observed that the algorithm works rather effectively here, with each character from the car’s number plate well segmented and distinguishable.

***Image 2 (“Plate8.jpg”)***

This image displays a zoomed-in car number plate with its characters clear, well-lit, and with letters and numbers separated into two rows. There is also a slight reflection from the plate as well as its logo and some shadows. The resulting segmentation by the algorithm is not as successful as the first image, with the top of each character slightly missing, the “1” has been heavily transformed but overall each character is still recognizable. There is also can additional column that has been produced as a result of splitting the two rows of letters and numbers.

***Image 3 (“Plate9.jpg”)***

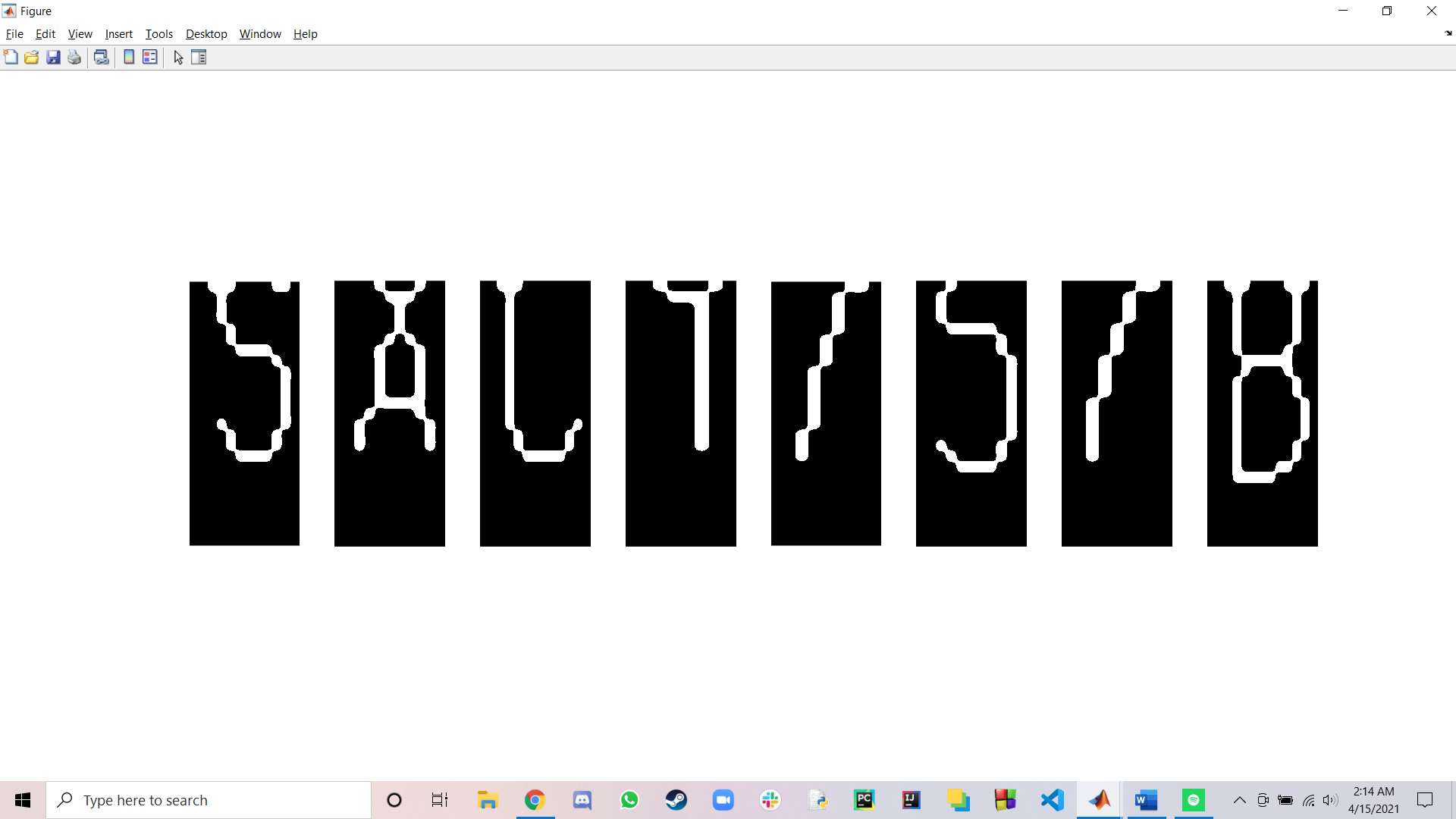
This is a similar image to image 2 but with the car number plate details more visible and less reflections. The algorithm works better here with no additional column produced and each character being fairly centralized and recognizable within its own segment. The “1” is still heavily transformed as is with image 2 above.

***Image 4 (“Plate23.jpg”)***

This is a slightly blurry image depicting a car number plate behind some criss crossing bars. In this scenario, the algorithm falls apart significantly based on the results of segmentation. The second “2” in “5228” has a bar overlapping it in the image which massively affected its skeletonization and rendered it unrecognizable in the final result. The pre-processing has also removed the “W” from the plate. The characters “8” and “B” look very similar and almost indistinguishable from each other. The “5” is not central within the segment, making its top unseen, and an empty segment has been produced.

***Image 5 (“Plate20.jpg”)***

This image contains more elements and objects in and around the subject. It is also rather bright and the car plate characters do not appear as clear as the other images. The algorithm performs decently here, with each of the characters successfully segmented into their own columns and the letters are well defined. The numbers are positioned too much towards the top of their segment, which cuts off the top portion slightly. The “1” looks close to a “Y” with its two prongs mostly cut off.

**Discussion/Critical Evaluation**

Based on the five results shown above, it can be noted that the algorithm works most effectively when the car number plate in the provided image is as central and visible as possible along with there having very little to no other elements/objects in the image. Elements/objects that interfere or interact heavily with the car number plate would lead to poor outline extraction and thus character segmentation by the algorithm. During pre-processing, blurry/noisy cropped images would result in characters that have interacting boundaries which causes the segmentation component to fail and produce columns with multiple characters within them. The pruning of the skeletonized image did not produce satisfactory results as certain characters, such as “1”, would be heavily transformed and become more unrecognizable. The bwmorph function with the “spur” parameter was used to execute pruning in 3 iterations which was decided to be the best number of iterations that would still result in the most appropriate removal of “spurious” edges. The pre-processing component of the algorithm is the most important as a cropped image that contains any element/object other than the car number plate would result in complete failure in the skeletonization and segmentation phase. Images with car number plates further away in the distance would result in ineffective crops that are similar to small zooms instead of capturing the plate only.

**Individual Member Contribution(s)**

**Cheah Meng Yew**

* LETTER/NUMBER SEPERATION coding contribution
* DOCUMENTATION on “Overall Methodology” and “Detailed Description”
* SEARCHING AND TESTING on additional Car Plates

**Yeow Kin Ren**

* Preprocessing of the image by using Harris Corner Detector Algorithm to retrieve the corner of highest contrast in the car plate detected
* Cropping of the boundary of the car plate using the preprocessed information and skeletonization and prunning of the image
* Elaborate on the documentation of the report

**Bryan Hooi Yu Ern**

* Cleaning and commenting code in the “Pre-Processing” and “Outline Extraction” sections.
* Writing the “Results” and “Discussion/Critical Evaluation” portion of the final report.
* Overall cleaning and structuring of content in the final report.