|  |
| --- |
| **HỌC VIỆN CÔNG NGHỆ BƯU CHÍNH VIỄN THÔNG**  **KHOA CÔNG NGHỆ THÔNG TIN**    **BÁO CÁO: NHẬP MÔN KHOA HỌC DỮ LIỆU**  **ĐỀ TÀI: NHẬN DIỆN BIỂN SỐ XE**  Giảng viên: Vũ Hoài Nam  Sinh viên: Đặng Ngọc Anh B21DCCN141  Ngô Hải Đăng B21DCCN201  Nguyễn Văn Hùng B21DCCN417  Nhóm: 12 - 02 |

**LỜI CẢM ƠN**

Chúng em xin gửi lời cảm ơn sâu sắc và chân thành nhất đến Thầy Vũ Hoài Nam, giảng viên môn *Nhập môn Khoa học Dữ liệu*, người đã luôn đồng hành và tận tình hướng dẫn chúng em trong suốt quá trình học tập và thực hiện đồ án này.

Trong suốt thời gian qua, thầy đã không ngừng truyền đạt những kiến thức nền tảng quan trọng của lĩnh vực khoa học dữ liệu, giúp chúng em xây dựng được nền móng vững chắc để tiếp cận một lĩnh vực đầy tiềm năng và thử thách. Không chỉ dừng lại ở việc cung cấp lý thuyết, thầy còn chia sẻ những kinh nghiệm thực tiễn quý giá, giúp chúng em hiểu rõ hơn cách áp dụng khoa học dữ liệu vào giải quyết các vấn đề trong thực tế.

Đặc biệt, trong quá trình thực hiện đồ án, thầy đã luôn theo sát, hỗ trợ chúng em với những góp ý chân thành, cụ thể và mang tính định hướng. Những lời khuyên của thầy không chỉ giúp chúng em vượt qua các khó khăn, bỡ ngỡ ban đầu, mà còn mở ra cho chúng em những cách nhìn mới mẻ và sáng tạo hơn trong việc triển khai dự án. Chính nhờ sự động viên, khích lệ của thầy mà chúng em đã có thêm động lực để hoàn thành đồ án này với tinh thần trách nhiệm và tâm huyết cao nhất.

Chúng em xin kính chúc thầy luôn dồi dào sức khỏe, hạnh phúc và thành công trong sự nghiệp giảng dạy cũng như trong các lĩnh vực mà thầy đam mê. Hy vọng rằng thầy sẽ tiếp tục truyền cảm hứng và dẫn dắt nhiều thế hệ sinh viên khác đạt được những thành công to lớn trong tương lai.

Trân trọng,  
Nhóm 12, lớp 02

**Lý do chọn đồ án**

Hiện nay, số lượng phương tiện giao thông trên đường rất lớn, dẫn đến việc quản lý xe cộ tại các bãi gửi xe trở nên phức tạp, tiêu tốn nhiều nguồn lực. Nếu thiếu các công cụ hỗ trợ hiệu quả, việc này không chỉ mất thời gian mà còn dễ gây sai sót, ảnh hưởng đến trải nghiệm của người sử dụng dịch vụ.

Để khắc phục các vấn đề như thu phí, bảo hiểm, hay tìm kiếm xe trong bãi đỗ, nhiều nơi trên thế giới đã ứng dụng công nghệ giám sát tự động. Biển số xe, với đặc tính riêng biệt, đã trở thành trọng tâm trong việc nghiên cứu và phát triển các giải pháp công nghệ này.

Do đó, nhóm em quyết định chọn đề tài này như một nền tảng để tìm hiểu thêm về các công cụ giám sát hiện đại hơn, chẳng hạn như nhận dạng xe trên đường hay nhận diện khuôn mặt – những lĩnh vực đang được thế giới đặc biệt chú ý.

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# GIỚI THIỆU

## Tổng quan

Nội dung nghiên cứu

* Nghiên cứu tổng quan về biển số xe và hệ thống nhận dạng biển số xe.
* Đưa ra phát biểu bài toán và đề xuất các phương pháp giải quyết.
* Tìm hiểu các thuật toán xử lý ảnh và nhận dạng ký tự, ứng dụng trong việc nhận diện biển số xe.

## Nhiệm vụ đề tài

Dựa trên nội dung nghiên cứu, đề tài tập trung vào các nhiệm vụ cụ thể sau:

* Nghiên cứu tổng quan về xử lý ảnh và bài toán nhận dạng biển số xe.
* Thu thập thông tin và phân loại các loại biển số xe tại Việt Nam.
* Phân tích quy trình nhận dạng biển số xe qua ba giai đoạn chính:
  + Xác định vị trí và tách biển số xe từ hình ảnh.
  + Phân đoạn ký tự trên biển số xe.
  + Nhận dạng và chuyển đổi ký tự thành mã ASCII.
* Tiến hành cài đặt và thử nghiệm giải pháp.

# TỔNG QUAN BÀI TOÁN NHẬN DIỆN BIỂN SỐ XE

## Khái niệm biển số xe

Tại Việt Nam, biển kiểm soát xe cơ giới (gọi tắt là biển số xe) là một tấm biển làm từ hợp kim nhôm sắt, gắn trên các phương tiện cơ giới. Biển số xe được cấp bởi cơ quan công an hoặc Bộ Quốc phòng (đối với xe quân sự) khi xe được mua mới hoặc chuyển nhượng. Trên biển số có in các ký tự chữ và số, mang thông tin về địa phương quản lý, danh tính chủ sở hữu, thời gian đăng ký, và các dữ liệu cần thiết phục vụ công tác an ninh.

Các tiêu chuẩn về kích thước biển số tại Việt Nam gồm hai loại:

* **Biển số dài**: 110 mm x 470 mm.
* **Biển số ngắn**: 200 mm x 280 mm.  
  Tỷ lệ chiều cao/rộng đối với biển số một hàng là từ 3.5 đến 6.5, còn với biển hai hàng là từ 0.8 đến 1.5. Biển số thường chứa từ 7 đến 9 ký tự, mỗi ký tự có kích thước tiêu chuẩn là 80 mm (chiều cao) x 40 mm (chiều rộng).

## Xử lý ảnh và Open CV

Xử lý ảnh, một nhánh của xử lý tín hiệu số, tập trung vào việc phân tích và cải thiện các tín hiệu dạng hình ảnh. Đây là lĩnh vực khoa học phát triển mạnh mẽ, ứng dụng rộng rãi trong đời sống như:

* Chỉnh sửa và nâng cao chất lượng ảnh.
* Nhận dạng đối tượng, chữ viết, khuôn mặt.
* Xử lý ảnh thiên văn và y tế.

OpenCV (Open Computer Vision) là thư viện mã nguồn mở hàng đầu trong lĩnh vực xử lý ảnh và thị giác máy tính. Được viết bằng C/C++, OpenCV có tốc độ xử lý nhanh, hỗ trợ đa nền tảng như Windows, Linux, macOS, Android và iOS. Thư viện này có nhiều ứng dụng như:

* Nhận dạng hình ảnh.
* Xử lý và phục hồi ảnh/video.
* Ứng dụng trong thực tế ảo.

## Hướng giải quyết

Để giải quyết bài toán nhận dạng biển số xe, đề tài tập trung vào ba bước chính:

1. Xác định vị trí và tách biển số từ hình ảnh đầu vào (camera).
2. Phân đoạn ký tự trên biển số.
3. Nhận diện ký tự và chuyển đổi thành mã ASCII.

A diagram of a diagram

Description automatically generated with medium confidence

*Hình 2.3 - 1 Các bước chính trong nhận dạng biển số xe*

# PHÁT HIỆN VỊ TRÍ VÀ TÁCH BIỂN SỐ XE

## Hướng giải quyết

Sơ đồ dưới đây sẽ tóm gọn các bước để xác định và tách biển số xe từ clip:

A black and white diagram

Description automatically generated

*Hình 3.1 - 1 Xác định và tách biển số xe*

Trước tiên, từ video đầu vào, từng khung hình (frame) sẽ được tách ra để xử lý và xác định biển số xe. Trong phạm vi đồ án, phương pháp chính dựa trên sự khác biệt rõ rệt về cường độ ánh sáng giữa biển số và môi trường xung quanh. Do đó, dữ liệu màu RGB sẽ được loại bỏ bằng cách chuyển đổi hình ảnh sang dạng ảnh xám.

Sau khi chuyển đổi, ảnh sẽ được tăng cường độ tương phản bằng hai phép toán hình thái học: **Top Hat** và **Black Hat**, nhằm làm nổi bật biển số giữa nền ảnh, hỗ trợ tốt hơn cho bước nhị phân hóa sau đó. Tiếp theo, bộ lọc Gauss được sử dụng để giảm nhiễu, loại bỏ các chi tiết không cần thiết, đồng thời cải thiện tốc độ xử lý.

Tiếp đến, ngưỡng động (**Adaptive Threshold**) sẽ được áp dụng để phân tách thông tin biển số khỏi nền ảnh. Sau đó, thuật toán phát hiện cạnh **Canny** sẽ được sử dụng để trích xuất các chi tiết cạnh của biển số. Trong quá trình xử lý, một số chi tiết nhiễu có thể bị nhầm lẫn với biển số. Việc lọc thêm bằng cách sử dụng tỷ lệ chiều cao/rộng hoặc diện tích của biển số sẽ giúp xác định chính xác vị trí. Cuối cùng, biển số được xác định bằng cách vẽ đường bao (**Contour**) xung quanh nó.

## Chuyển ảnh xám

**Ảnh xám (Gray Scale)** là hình ảnh với các sắc thái của màu xám, gồm 256 cấp độ từ đen (giá trị 0) đến trắng (giá trị 255). Mỗi điểm ảnh (pixel) trong ảnh xám được biểu diễn bằng 1 byte (8 bits), khác với ảnh màu thông thường cần đến 3 trường thông tin cho mỗi pixel. Việc giảm bớt thông tin này giúp tăng tốc độ xử lý và đơn giản hóa các thuật toán mà vẫn đảm bảo thực hiện được các tác vụ quan trọng.

Trong bài toán này, ảnh xám được chuyển đổi từ hệ màu **HSV** thay vì **RGB**. Hệ màu HSV bao gồm ba thành phần chính:

* **Hue** (vùng màu),
* **Saturation** (độ bão hòa),
* **Value** (cường độ sáng).

Hệ màu HSV thích nghi tốt hơn với sự thay đổi ánh sáng từ môi trường. Khi chuyển sang ảnh xám, ta sử dụng ma trận giá trị cường độ sáng (**Value**) được tách ra từ hệ màu HSV.

## Tăng độ tương phản

### Phép toán hình thái học

**Hình thái học toán học** là một phương pháp phân tích và xử lý các cấu trúc hình học trong ảnh. Kỹ thuật này dựa trên các phần tử cấu trúc (**structuring elements/kernel**) để xác định và cải thiện các chi tiết quan trọng.

A group of squares with black dots

Description automatically generated

*Hình 3.3 - 1 Ví dụ về phần tử cấu trúc*

Trong đồ án, hai phép toán hình thái học được sử dụng là:

1. **Top Hat**: Làm nổi bật các chi tiết sáng hơn nền.
2. **Black Hat**: Làm nổi bật các chi tiết tối hơn nền.

#### Phép co

Phép toán này làm giảm kích thước đối tượng trong ảnh, giúp tách rời các đối tượng gần nhau, làm mảnh các chi tiết hoặc tìm "xương" của đối tượng.

|  |  |
| --- | --- |
| A white letter on a black background  Description automatically generated | A white letter on a black background  Description automatically generated |
| Ảnh gốc | Ảnh sau khi dùng phép co |

*Hình 3.3 - 2 Phép co*

#### Phép giãn nở

Phép giãn nở làm tăng kích thước của đối tượng trong ảnh, lấp đầy các lỗ nhỏ và nối liền các đoạn rời rạc trên đường biên. Kết quả là đối tượng trong ảnh trở nên lớn hơn, liên tục hơn.

|  |  |
| --- | --- |
| A white letter on a black background  Description automatically generated | A white letter on a black background  Description automatically generated |
| Ảnh gốc | Ảnh sau khi dùng phép giãn nở |

*Hình 3.3 - 3 Phép giãn nở*

#### Phép mở

Được thực hiện bằng cách áp dụng phép co trước, sau đó là phép giãn nở. Phép toán này giúp loại bỏ các phần lồi lõm, làm mượt đường bao của đối tượng, giảm nhiễu và giữ nguyên cấu trúc chính của đối tượng.

|  |  |
| --- | --- |
| A white letter on a black background  Description automatically generated | A white letter on a black background  Description automatically generated |
| Ảnh gốc | Ảnh sau khi dùng phép mở |

*Hình 3.3 - 4 Phép mở*

#### Phép đóng

Được thực hiện bằng cách áp dụng phép giãn nở trước, sau đó là phép co. Phép toán đóng giúp làm trơn đường bao, lấp đầy các khoảng trống nhỏ ở biên và loại bỏ các hố nhỏ trong đối tượng.

|  |  |
| --- | --- |
| A white letter on a black background  Description automatically generated | A white letter on a black background  Description automatically generated |
| Ảnh gốc | Ảnh sau khi dùng phép đóng |

*Hình 3.3 - 5 Phép đóng*

#### Phép Top Hat

Là kết quả của việc trừ ảnh gốc với ảnh sau khi thực hiện phép mở. Phép toán này làm nổi bật các chi tiết sáng trong nền tối.

|  |  |
| --- | --- |
| A close-up of a motorcycle  Description automatically generated | A close-up of a motorcycle  Description automatically generated |
| Ảnh gốc | Ảnh sau khi dùng phép Top Hat |

*Hình 3.3 - 6 Phép Top Hat*

#### Phép Black Hat

Là kết quả của việc trừ ảnh sau khi thực hiện phép đóng với ảnh gốc. Phép toán này làm nổi bật các chi tiết tối trong nền sáng.

|  |  |
| --- | --- |
| A close-up of a motorcycle  Description automatically generated | A license plate on a motorcycle  Description automatically generated |
| Ảnh gốc | Ảnh sau khi dùng phép Black Hat |

*Hình 3.3 - 7 Phép Black Hat*

### Tăng độ tương phản

Để tăng độ tương phản của biển số xe, ta áp dụng hai phép toán Top Hat và Black Hat. Ảnh kết quả được tạo bằng cách cộng ảnh gốc với ảnh qua phép Top Hat và trừ đi ảnh qua phép Black Hat. Kết quả làm chi tiết sáng trở nên sáng hơn và chi tiết tối càng tối hơn, giúp tăng độ tương phản và làm nổi bật biển số trong ảnh.

|  |  |
| --- | --- |
|  | A close-up of a motorcycle  Description automatically generated |
| Ảnh gốc | Ảnh sau khi tăng độ tương phản |

*Hình 3.3 - 8 Ảnh sau khi tăng độ tương phản*

## Giảm nhiễu bằng bộ lọc Gauss

### Nhiễu

Nhiễu (Noise) là các dạng chấm hạt nhỏ phân bố trên ảnh, làm biến dạng chi tiết và giảm chất lượng hình ảnh. Nhiễu thường được phân thành ba loại chính:

1. Nhiễu cộng (Additive Noise).
2. Nhiễu nhân (Multiplicative Noise).
3. Nhiễu xung (Impulse Noise).

Do nhiễu thường tương ứng với các tín hiệu tần số cao, các bộ lọc như lọc thông thấp hoặc lọc trung bình được sử dụng để loại bỏ nhiễu.



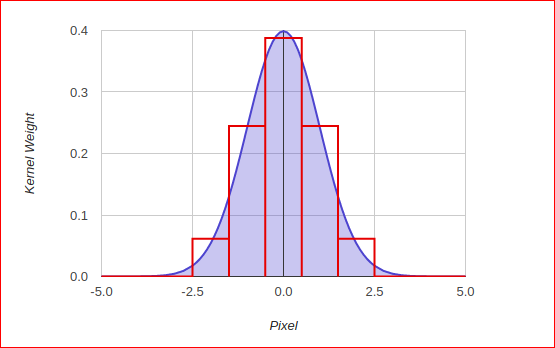
*Hình 3.4 - 1 Nhiễu*

### Bộ lọc Gauss (Gauss filter)

Bộ lọc Gauss là một trong những phương pháp phổ biến và hiệu quả nhất để giảm nhiễu. Phương pháp này thực hiện bằng cách nhân chập ảnh đầu vào với một ma trận Gauss và cộng kết quả để tạo ra ảnh đầu ra.

Ý tưởng chính:

* Giá trị của một điểm ảnh trung tâm phụ thuộc nhiều vào các điểm ảnh xung quanh nó.
* Trọng số của các điểm ảnh gần trung tâm cao hơn so với các điểm xa, theo quy luật của hàm Gauss (phân phối chuẩn).
* Điểm ảnh gần trung tâm đóng góp lớn hơn vào giá trị trung tâm, trong khi các điểm xa hơn có ảnh hưởng ít hơn.



*Hình 3.4 - 2 Ma trận lọc Gauss*

Trong không gian một chiều, điểm ảnh ở trung tâm có trọng số lớn nhất. Khi khoảng cách từ điểm ảnh đến trung tâm tăng lên, trọng số giảm dần, giúp giảm thiểu nhiễu và làm mịn ảnh hiệu quả.

|  |  |
| --- | --- |
|  | A close-up of a motorcycle  Description automatically generated |
| Ảnh gốc | Ảnh sau khi làm mờ, giảm nhiễu |

*Hình 3.4 - 3 Kết quả sử dụng bộ lọc Gauss*

## Nhị phân hóa với ngưỡng động (Adaptive Threshold)

### Ảnh nhị phân

Ảnh nhị phân là ảnh mà mỗi điểm ảnh chỉ có hai giá trị:

* 0 (đen) hoặc 255 (trắng).

### Nhị phân hóa

Nhị phân hóa ảnh là quá trình chuyển đổi ảnh xám thành ảnh nhị phân.

Nguyên tắc: So sánh cường độ sáng I(x,y)I(x, y)I(x,y) của từng điểm ảnh với một ngưỡng TTT:

* Nếu I(x,y) > TI(x, y) > TI(x,y) > T, gán giá trị điểm ảnh nhị phân INP(x,y) = 255
* Ngược lại, INP(x,y) = 0

### Nhị phân hóa với ngưỡng động

Khác với ngưỡng toàn cục, nhị phân hóa ngưỡng động tự động tính toán ngưỡng TTT phù hợp cho từng vùng của ảnh. Điều này hữu ích khi ảnh có vùng quá sáng hoặc quá tối, giúp giảm mất chi tiết..

Ý tưởng chính:

1. Chia ảnh thành nhiều khu vực nhỏ.
2. Tìm ngưỡng TTT phù hợp cho mỗi khu vực.
3. Áp dụng nhị phân hóa riêng cho từng khu vực với ngưỡng đã tính.

Phương pháp: Sử dụng thuật toán ADAPTIVE\_THRESH\_GAUSSIAN\_C (trong OpenCV), tính trung bình các giá trị xung quanh điểm đang xét theo phân phối Gauss, rồi trừ đi một hằng số CCC.

A close-up of a motorcycle

Description automatically generated

*Hình 3.5 - 1 Nhị phân hóa ảnh ngưỡng động*

## Phát hiện cạnh Canny (Canny Edge Detection)

Phát hiện cạnh giúp trích xuất các biên, một đặc trưng quan trọng trong ảnh. Canny Edge Detection vượt trội hơn các phương pháp khác như Sobel, Prewitt do:

1. Ít bị ảnh hưởng bởi nhiễu.
2. Nhận diện được các biên yếu.
3. Giảm nhiễu (Noise reduction)
4. Tính toán Gradient (Gradient calculation)
5. Loại bỏ những điểm không phải là cực đại (Non-maximum suppression)
6. Lọc ngưỡng (Double threshold)

### Giảm nhiễu

Làm mờ ảnh, giảm nhiễu dùng bộ lọc Gauss kích thước 5x5. Kích thước 5x5 thường hoạt động tốt cho giải thuật Canny

### Tính toán Gradient

Ta dùng 2 bộ lọc Sobel X và Sobel Y (3x3) để tính đạo hàm Gx và Gy

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|  |  |

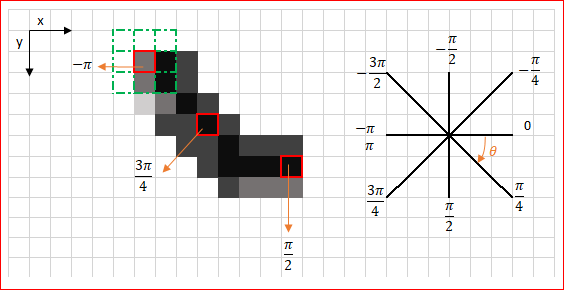
Tìm gradient và hướng được làm tròn về 4 hướng: hướng ngang (0 độ), hướng chéo bên phải (45 độ), hướng dọc (90 độ) và hướng chéo trái (135 độ).

|  |  |
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### Loại bỏ những điểm không phải là cực đại

Kiểm tra từng điểm trên ảnh Gradient.

Chỉ giữ điểm có độ lớn Gradient là cực đại so với hai pixel lân cận theo hướng Gradient.



*Hình 3.6 - 1 Loại bỏ những điểm không phải cực đại*

### Lọc ngưỡng

Ngưỡng cao (max\_val): Điểm có Gradient lớn hơn được giữ lại.

Ngưỡng thấp (min\_val): Điểm có Gradient thấp hơn bị loại bỏ.

Điểm trong khoảng giữa hai ngưỡng:

* Giữ lại nếu liền kề điểm thuộc ngưỡng cao.
* Loại bỏ nếu không liền kề.

### Kết quả

Sau khi phát hiện biên, nhiều chi tiết thừa vẫn còn. Từ đây, ta vẽ contour và áp dụng các đặc điểm của biển số để lọc.

A black and white image of a motorcycle

Description automatically generated

*Hình 3.6 - 3 Ảnh sau khi phát hiện biên Canny*

## Lọc biển số với contour

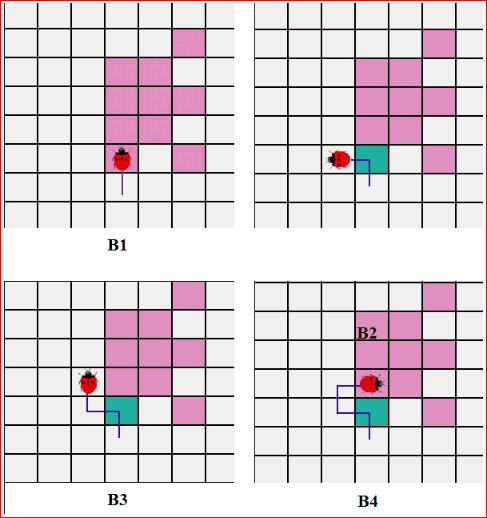
### Một số phương pháp tìm contour

Contour là tập hợp các điểm tạo thành đường cong khép kín bao quanh một đối tượng, giúp xác định đặc trưng và vị trí của đối tượng trong ảnh

#### Thuật toán Square Tracing

Dò pixel từ cạnh dưới bên trái, gặp pixel giá trị 255 (bắt đầu), di chuyển theo quy tắc:

* Pixel 255: rẽ trái.
* Pixel 0: rẽ phải.



*Hình 3.7 - 1 Thuật toán Square Tracing*

Dừng khi quay lại pixel ban đầu đúng hướng.

|  |  |
| --- | --- |
| A screenshot of a game  Description automatically generated  *Hình 3.7 - 2 Thuật toán Square Tracing  chạy đúng* | A screenshot of a game  Description automatically generated  *Hình 3.7 - 3 Thuật toán Square Tracing  chạy sai* |

#### Thuật toán Moore – Neighbor

Tương tự Square Tracing nhưng duyệt theo các pixel 8-connected (đi qua mọi hướng xung quanh).

A grid with ladybugs on it

Description automatically generated

*Hình 3.7 - 4 Thuật toán Moore - Neighbor.*

#### Thuật toán Suzuki’s Tracing

Đây là thuật toán được thư viện OpenCV sử dụng, ngoài khả năng xác định được biên của vật thể như hai phương pháp trên. Phương pháp Suzuki’s Tracing còn có khả năng phân biệt được đường biên ngoài (Outer) và đường biên trong (Hole) của vật thể.

A close-up of a motorcycle

Description automatically generated

*Hình 3.7 - 5 Vẽ Contour với OpenCV*

Trong ảnh, những đường màu hồng là đường contour bao quanh vật thể, nhưng vì có quá nhiều đường bao quanh các vật thể không phải biển số nên chúng ta sẽ áp dụng những đặc trưng riêng về tỉ lệ cao/rộng, diện tích trong khung hình cố định như ở mục 2.1 để lọc ra đúng biển số cần tìm.

### Lọc biển số

Chỉ lấy những contour có 4 cạnh (hình tứ giác).

|  |  |
| --- | --- |
| A red and green rectangular sign  Description automatically generated  *Hình 3.7 - 6 Contour chưa xấp xỉ đa giác* | A red and black rectangle with black lines  Description automatically generated  *Hình 3.7 - 7 Contour đã xấp xỉ đa giác* |

Lọc các contour dựa trên tỉ lệ và diện tích phù hợp với biển số thực tế.

Dựa vào tọa độ của contour đã lọc, cắt vùng biển số. Sử dụng ảnh nhị phân để giảm thời gian xử lý.

# PHÂN ĐOẠN KÍ TỰ

## Hướng giải quyết

Ở giai đoạn này có những bước chính sau: Xoay biển số để tăng khả năng nhận diện, Tìm tất cả các vùng kín cho là kí tự và lọc ra những kí tự đúng. Tách hình ảnh nhưng kí tự đó ra và đưa vào bộ nhận diện

A black and white sign with arrows

Description automatically generated

*Hình 4.1 - 1 Các bước chính trong phân đoạn kí tự*

## Xoay biển số

Khi chụp ảnh đầu vào, không phải lúc nào biển số cũng ở chính diện, có thể bị méo sang trái, sang phải, nghiêng góc dẫn đến nếu cứ sử dụng ảnh biển số đã cắt mà không điều chỉnh góc độ dẫn đến ảnh kí tự được cắt ra đưa vào bộ nhận diện rất dễ bị sai. Ví dụ giữa số 1 và số 7, số 2 và chữ Z, chữ B và số 8,...

A close up of a license plate

Description automatically generated

*Hình 4.2 - 1 Ảnh biển số chưa xoay*

Phương pháp xoay ảnh em sử dụng ở đây là:

1. Lọc ra tọa độ 2 đỉnh A,B nằm dưới cùng của biển số
2. Từ 2 đỉnh có tọa độ lần lượt là A(x1, y1) và B(x2,y2) ta có thể tính được cạnh đối và cạnh kề của tam giác ABC
3. Ta tính được góc quay
4. Xoay ảnh theo góc quay đã tính. Nếu ngược lại điểm A nằm cao hơn điểm B ta cho góc quay âm

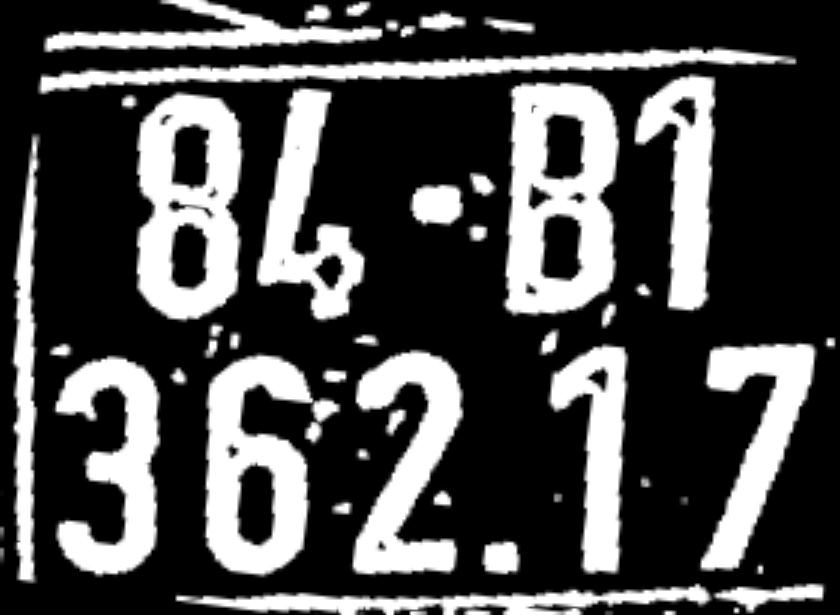
A close up of a license plate

Description automatically generated

*Hình 4.2 - 2 Ảnh biển số đã xoay*

## Tìm vùng đối tượng

Từ ảnh nhị phân, ta lại tìm contour cho các kí tự (phần màu trắng). Sau đó vẽ những hình chữ nhật bao quanh các kí tự đó. Tuy nhiên việc tìm contour này cũng bị nhiễu dẫn đến việc máy xử lý sai mà tìm ra những hình ảnh không phải kí tự. Ta sẽ áp dụng các đặc điểm về tỉ lệ chiều cao/rộng của kí tự, diện tích của kí tự so với biển số



*Hình 4.3 - 1 Ảnh nhị phân*

A close-up of numbers

Description automatically generated

*Hình 4.3 - 2 Tìm vùng đối tượng*

Trong ảnh 4.3 - 2 những đường màu vàng là đường contour và nếu so sánh với ảnh nhị phân 4.3 -1 thì có rất nhiều đường nhiễu như đường viền biển số, dấu gạch, dấu chấm... Sau khi đã áp dụng các điều kiện thì sẽ vẽ ra những hình chữ nhật màu xanh bao quanh các kí tự.

## Tìm và tách kí tự

Sau khi đã nhận dạng từng kí tự bằng hình chữ nhật và cũng đã có tọa độ vị trí 4 đỉnh của hình đó, ta lúc này có thể cắt hình ảnh kí tự đó ra phục vụ cho giai đoạn sau “Nhận diện kí tự”. Lưu ý ở đây ta cắt ảnh nhị phân chứ không cắt từ ảnh gốc.

A white line on a black background

Description automatically generated

*Hình 4.4 - 1 Ảnh kí tự sau khi cắt*

# NHẬN DIỆN KÍ TỰ

Thực chất quá trình nhận diện kí tự chính là quá trình chuyển đổi từ một hình ảnh là ma trận giá trị các điểm ảnh về một dạng thông tin khác như trong đề tài này là mã ASCII để có thể giao tiếp với người dùng. Để hiểu hơn về nhận diện, chúng ta cần đi ngược lại về ngành khoa học trí tuệ nhân tạo (Artificial Intelligent) hay còn gọi là AI

## Hướng giải quyết

Tạo tập dữ liệu huấn luyện

* Sử dụng phần mềm Paint để tạo tập dữ liệu các kí tự và chữ số:
  + Các kí tự trừ O, I, J
  + Phông chữ: "Biển số xe Việt Nam".
  + Xoay các kí tự theo các góc: +- 5 độ, +- 10 độ

A group of letters on a white background

Description automatically generated

*Hình 5.2 - 1 Tập dữ liệu huấn luyện*

Sau đó:

* Lấy ngưỡng.
* Vẽ contour và cắt từng kí tự.

Chuẩn hóa kích thước từng kí tự thành 30×20 pixel (tỉ lệ cao:rộng là 30:20).

Gắn nhãn bằng cách sử dụng phím bấm trên máy tính.

Dữ liệu lưu trữ:

* File classifications.txt: Lưu mã ASCII của các kí tự.
* File flattened\_images.txt: Lưu giá trị điểm ảnh của hình ảnh kí tự (600 điểm ảnh 30×2030 \times 2030×20, mỗi điểm có giá trị 0 hoặc 255).

Phân biệt biển một hàng và hai hàng:

* Dựa vào vị trí của các kí tự:
  + Nếu vị trí nằm thấp hơn 1/3 chiều cao biển số: Kí tự thuộc hàng một.
  + Ngược lại: Kí tự thuộc hàng hai.

Hiển thị kết quả dưới dạng hình ảnh.

|  |  |
| --- | --- |
| A close-up of a number  Description automatically generated  *Hình 5.2 - 2 Biển số trước khi nhận diện* | A close-up of a number  Description automatically generated  *Hình 5.2 - 3 Biển số sau khi nhận diện* |

A close-up of a motorcycle

Description automatically generated

*Hình 5.2 - 4 Biển số xe được in ra trên hình gốc*

# KẾT QUẢ THỰC HIỆN

## Cách thức đo đạc, thử nghiệm

Tổng biển số =. (Y = 3 với biển 2 hàng, Y = 1 với biển một hàng).

Tỉ lệ tìm thấy biển số xe = 100 (%)

Ta sẽ tìm tỉ lệ biển sai n kí tự trên tổng số biển bắt được trong clip. Lưu ý sai ở đây nghĩa là kí tự bị nhận diện sai, không khoanh được vùng hoặc khoanh vùng kí tự sai vị trí.

Tỉ lệ nhận diện = 100 (%)

## Kết quả và giải thích

|  |  |  |  |
| --- | --- | --- | --- |
| Loại biển | Tổng biển số | Số biển  tìm thấy | Tỉ lệ tìm thấy biển số xe (%) |
| Biển 1 hàng | 185 | 91 | 49,2% |
| Biển 2 hàng | 1174 | 462 | 39,3% |

Bảng 6.1 - 1 Tỉ lệ tìm thấy biển số xe trong hình

Đánh giá hiệu quả nhận diện biển số: Biển một hàng và hai hàng

Biển số một hàng

* Ưu điểm:
  + Tỉ lệ nhận diện cao hơn do:
    - Tập mẫu nhỏ hơn: Ít biến thể hơn, dễ huấn luyện và nhận diện.
    - Mỗi khung hình (frame ảnh) chỉ chứa một biển số, nên:
      * Biển số thường nằm ở vị trí trung tâm.
      * Ít nhiễu hơn, giúp nhận diện chính xác hơn.

Biển số hai hàng

* Thách thức:
  + Tập mẫu lớn hơn: Biến thể đa dạng hơn, tăng độ phức tạp khi nhận diện.
  + Mỗi frame ảnh chứa nhiều biển số, dẫn đến:
    - Vị trí biển số không cố định, khó xử lý.
  + Biển số được xác định là vùng hình bình hành, với điều kiện:
    - Phải có tối thiểu 7 kí tự mới được tính là biển số.
    - Nhiều biển số dù đã được cắt chính xác nhưng vẫn không thỏa mãn điều kiện này, dẫn đến bị loại.

Hiệu quả và cải thiện

* Cách làm hiện tại:
  + Dù tỉ lệ nhận diện biển số hai hàng thấp hơn, phương pháp này giúp:
    - Loại bỏ đáng kể các chi tiết nhiễu hoặc biển số không hợp lệ từ môi trường.
    - Tăng độ chính xác của các biển số hợp lệ trong tập dữ liệu đầu ra.
* Định hướng cải thiện:
  + Mở rộng và cân bằng tập mẫu cho cả biển số một hàng và hai hàng.
  + Tối ưu thuật toán xác định vùng biển số để giảm loại bỏ sai các biển số hợp lệ.

|  |  |
| --- | --- |
| A white rectangular sign with black numbers  Description automatically generated  *Hình 6.2 - 1 Không tìm thấy kí tự* | A license plate on a motorcycle  Description automatically generated  *Hình 6.2 - 2 Ảnh gốc* |
| A screenshot of a computer  Description automatically generated  *Hình 6.2 - 3 Tìm thấy 5 kí tự* |
| A close-up of a license plate  Description automatically generated  *Hình 6.2 - 4 Tìm thấy 9 kí tự* |

Vấn đề gặp phải trong nhận diện biển số

1. Ảnh hưởng của góc quay và vị trí biển số:
   * Khi biển số quay theo nhiều góc độ hoặc ở các vị trí bất lợi, các đặc trưng như diện tích hoặc tỉ lệ cao/rộng không thỏa mãn các điều kiện đặt ra.
   * Điều này dẫn đến nhiều biển số bị loại bỏ nhầm.
2. Sai lệch trong xấp xỉ contour:
   * Biển số bị ảnh hưởng bởi chi tiết ngoài, đặc biệt ở xe ô tô:
     + Vùng nền xung quanh biển số thường làm bằng vật liệu phản chiếu ánh sáng, gây nhiễu lớn khi xác định vùng biển số.
   * Hình dạng contour không đủ tứ giác:
     + Xấp xỉ contour có thể tạo thành hình 2 hoặc 3 cạnh thay vì hình tứ giác cần thiết, làm mất biển số hợp lệ.
3. Ảnh hưởng của nhiễu và điều kiện biển số:
   * Biển số bị tối, bụi bẩn hoặc ảnh có nhiều nhiễu gây khó khăn trong:
     + Quá trình xử lý nhị phân: Đường biên bị đứt đoạn, tạo contour sai.

|  |  |
| --- | --- |
| A close up of a motorcycle  Description automatically generated  *Hình 6.2 - 5 Lấy ngưỡng cao/rộng 1.5* | A license plate on a motorcycle  Description automatically generated  *Hình 6.2 - 6 Lấy ngưỡng cao/rộng 1.4* |

![A license plate with black numbers and pink neon lights

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDQRXhpZgAATU0AKgAAAAgABAE7AAIAAAADVlAAAIdpAAQAAAABAAAISpydAAEAAAAGAAAQwuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFkAMAAgAAABQAABCYkAQAAgAAABQAABCskpEAAgAAAAM3NQAAkpIAAgAAAAM3NQAA6hwABwAACAwAAAiMAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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W4PH/oVNxB6D8zXuQ8E+GkUKNLt8KMDJJP5k81PD4V8OwIVTSrAgnPzwq5/M5qXmEX/wAvan3pfqKWaQe9eq/ml+rPBgIexFGYO+PyNe+f8I54e/6BWmf+A0f+FSppujwRhI7WyjQdFWJQB+GKzeNpXu51H/29/wABmTzGi3dzqv8A7fX+TPAPMt8dFP8AwGlj2SuEgjZ3boqJkmvoKOPT7Zi8At4mxglFAOPwpxvLQdZ0/Os3i8Pa3LN+s/8A7UxeOwtrcs361P8AKJ4CbO57WN1/35NSR6Nqsy74NIvpF/vLbMR+gr3k39mOs6/hTTqNiP8Alv8ApUfWqH/Pt/8AgTI+u4X/AJ8v5zf/AADwv+wta76LqP8A4Cv/AIVYXwr4gZQy6Nc4IyMjB/Kvav7VsB1mP5Uw6zYDo7H8Kn6xhltRX3y/zRn9bwi2w6+cpfo0eNp4Q8RyuEXSJgT03Mqj8ycVOPAnickD+ygM9zcR8f8Aj1etnXbEdmNRt4hsx0Q/nR9apL4aMf8AyZ/+3B9eor4cPD587/8AbjzD/hXniMf8sbX/AL/VJF8OPEMpIf7FBju8hOfyBr0hvEVr2j/Wo28SQjog/wC+qX11dKUPu/4I/wC0F0ow+7/gnn//AArLXx/y9ad/32//AMRT4/hjrjOBLeWKL3Kl2I/AqK7R/F9shI3QgjrlxVaTxzZqSDdWwI7GQf41osTVl8NKP/gJrHF1pfDQj/4Ajmh8LtTH/MUt/wDv2aX/AIVdqn/QUt/+/Rral8f2inH2uH/gJzVWT4iWgYg3n/fMbH+lbRnjJfDQT/7hr/I3jPMJ/Dh0/wDuEv8A5Eqp8K7kqDJrYVu4W2yPz3Crtv8AC+1Vh9r1K6nTHzouEDH9cCqUnxFt92BPIw9Qh/rWe3xRsj1ll/76T/4qtV/afSHL/wBuxX6JmyWc2uqfL/25GP6JnY23gLQbVABYLKc5LSsWJ/pXznXpU3xcsNjMLmI47fal/pXmtfLZ9HEp03iHffrft5ux9pwnHGJ13ipNt8tryT/m83Y9F0v4vXemaTZ2KaeXW1gSEN9pxkKoGcbeOlW/+F2X3/QNP/gV/wDYUUV4qxtdKyl+CPWnwzlM5OUqWr/vS/zD/hdt/wD9A4/+BX/2FJ/wuy//AOgef/An/wCwoop/XsR/N+C/yJ/1Wyf/AJ8/+TS/+SE/4XXf/wDQPP8A4E//AGFJ/wALqv8A/oHn/wACf/sKKKPr2I/m/Bf5B/qtk/8Az5/8ml/8kH/C6r//AKB5/wDAn/7Gmn40X5/5cD/4E/8A2NFFH17Efzfgv8g/1Wyf/nz/AOTS/wDkhp+Ml8etg3/gT/8AY00/GG+P/Li3/gT/APY0UUfXsR/N+C/yD/VbJ/8Anz/5NL/5IT/hb95/z4N/4Ff/AGNIfi7eH/lwb/wJ/wDsaKKPr2I/m/Bf5B/qtk//AD5/8ml/8kMPxavD/wAuLf8AgT/9jTf+Fr3R62Df+BP/ANjRRR9exH834IP9Vsn/AOfP/k0v/khP+Fq3P/QPP/gT/wDY00/FK4P/ADD/APyY/wDsaKKPr2I/m/BB/qtk/wDz5/8AJpf/ACRG/wAT7sn5LFQPeUn+lMPxNvT/AMucf/fw/wCFFFUswxK+1+C/yLXDOUJW9ivvl/mMf4k6gfuWsS/ViaZ/wsjU/wDn3g/Nv8aKKtZnil1X/gMf8i1w7lSVvYr8f8xj/ETVHxiONfp3/Ooz4/1Q9l/z+FFFWs2xa6r/AMAh/wDImiyHK0rewj9wx/HeqsOG2/TH9RTP+E21X/nq3/jv/wATRRVrOcYla8f/AACH/wAiaLJctSt7CP3IjPjDUj1ml/7+f/WqofEurf8AP2//AH2//wAVRRWn9vZh0ml/27Bf+2mv9l4JbUkvRW/IrSa3rLuWF3Fz/ejcn899U/terF8tfQ4zkgW/9d1FFH9v5mtqzXpZfoH9m4ZbJr0lJfkxWnv2lyNRmVM/dEcfT0ztpVaQSFnvL189jKgA/JBRRVf6w5p1rP8AB/oV/Z+H6pv1lJ/mxwMZJMjXj5/6fHXH/fOKY8NjIwZ7ediO5vJCT9eeaKKHxBmL3mn/ANuw/wDkQeXYNqzpp+quJJDZFtyafbljwTMvmcfjTcGL/j0tdOhz97/RM5/JhRRUvP8AMf8An5b0jFfkhPLMHuoJel1+Qnnaiv8Ax7z2dv6+VaY3fXLVJRRXDi8wxWMt9YnzW28r7/kdFDDUsPf2d9fNv827fI//2Q==)

*Hình 6.2 - 7 Lỗi xấp xỉ Contour*

Ở hình 6.2 - 7 Contour màu hồng bao quanh biển số nhưng sau khi xấp xỉ chỉ còn hình 2–3 cạnh, do mức ngưỡng chưa tối ưu.

Trong quá trình xử lý, việc xử lý nhị phân cũng đóng vai trò quan trọng, ở hình 6.2 – 9. Ảnh biển số bị nhiễu và tối, đường contour sai do đứt đoạn trong quá trình nhị phân.

|  |  |
| --- | --- |
| A black and white photo of numbers  Description automatically generated  *Hình 6.2 - 8 Ảnh nhị phân bị đứt* | A digital display with numbers and symbols  Description automatically generated  *Hình 6.2 - 9 Đường contour bị đứt đoạn* |

Dưới đây ta xét khả năng khoanh vùng và nhận diện kí tự tương ứng với giai đoạn “Phân đoạn kí tự” và “Nhận diện kí tự” đã đặt ra ở đầu bài toán.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Loại biển | Số biển tìm thấy | Không sai | Sai 1 kí tự | Sai 2 kí tự | Sai 3 kí tự  trở lên |
| Biển 1 hàng | 182 | 60 | 88 | 18 | 16 |
| Tỉ lệ (%) | | 33,1 | 52,2 | 9,8 | 4,9 |

Bảng 6.1 - 2 Tỉ lệ nhận diện sai kí tự ở biển 1 hàng

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Loại biển | Số biển tìm thấy | Không sai | Sai 1 kí tự | Sai 2 kí tự | Sai 3 kí tự  trở lên |
| Biển 2 hàng | 924 | 286 | 273 | 175 | 190 |
| Tỉ lệ nhận diện (%) | | 31 | 29,5 | 18,9 | 20,6 |

Bảng 6.1 - 3 Tỉ lệ nhận diện sai kí tự ở biển 2 hàng

Hiệu quả của mô hình KNN

* Khả năng nhận diện tốt với kí tự mờ hoặc nghiêng:
  + Mô hình KNN cho kết quả khả quan ngay cả khi kí tự bị mờ hoặc bị nghiêng trong khoảng từ 3° đến 7°.
  + Điều này đạt được nhờ vào bước xoay biển số về vị trí chuẩn trước khi đưa vào nhận diện.

Hạn chế của mô hình KNN

Nhầm lẫn giữa các kí tự tương tự:

* + Các cặp kí tự có đặc điểm hình dạng gần giống nhau thường bị nhận diện sai:
    - Số 1 và số 7.
    - Chữ G và chữ D.
    - Số 6 và số 0.
    - Chữ B và số 8.

![A license plate on a motorcycle

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDQRXhpZgAATU0AKgAAAAgABAE7AAIAAAADVlAAAIdpAAQAAAABAAAISpydAAEAAAAGAAAQwuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFkAMAAgAAABQAABCYkAQAAgAAABQAABCskpEAAgAAAAMyMwAAkpIAAgAAAAMyMwAA6hwABwAACAwAAAiMAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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*Hình 6.2 - 10 Ảnh gốc nhận diện 3 biển số*

|  |  |  |
| --- | --- | --- |
| A close-up of numbers  Description automatically generated  *Hình 6.2 - 11 Biển số 1* | A white sign with numbers and green border  Description automatically generated  *Hình 6.2 - 12 Biển số 2* | A close-up of numbers  Description automatically generated  *Hình 6.2 - 13 Biển số 3* |

Theo như hình gốc 6.2 - 10 ta nhận diện đúng hết biển số 2 và 3. Còn biển số 1 bị sai giữa chữ B và số 8

![A close up of numbers

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDQRXhpZgAATU0AKgAAAAgABAE7AAIAAAADVlAAAIdpAAQAAAABAAAISpydAAEAAAAGAAAQwuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFkAMAAgAAABQAABCYkAQAAgAAABQAABCskpEAAgAAAAM2NwAAkpIAAgAAAAM2NwAA6hwABwAACAwAAAiMAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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P+f65/7/N/jXPDHYyF+Wpu77IKeT4+nzcuK3d37i3/APAj3f8A4Tc9rX/x6mnxsx/5dv1rwr+1dQ/5/rn/AL/N/jR/auof8/1z/wB/m/xqv7Qx3/Pz8EV/ZWYv/mL/APJF/me5/wDCaSf88P1pD4zlPSH9a8N/tXUP+f65/wC/zf40f2rqH/P9c/8Af5v8an69jf8An7+BP9j5i/8AmM/8kX/yR7efGMx/5Zn86xpLm2kkZ/IcFiScPXlP9q6h/wA/1z/3+b/Gj+1dQ/5/rn/v83+Nc9WtiK1vaTvbukc1bh3FYhJVcTzW7wX/AMkep+db/wDPJ/8AvunxTW3mr5kcmzPPz15T/auof8/1z/3+b/Gj+1dQ/wCf65/7/N/jWChK+6+5HL/qjK9/bL/wBf8AyR7P5mijok3/AH9NNMuj9o5v+/xrxr+1dQ/5/rn/AL/N/jR/auof8/1z/wB/m/xrp9o/5Y/+Ao6/9Wn/ADx/8Fr/AOSPZDNpHaKb/v8AGmm40kf8sJv+/wAa8d/tXUP+f65/7/N/jR/auof8/wBc/wDf5v8AGp5pdo/+Aol8My/5+R/8Fr/5I9gNzpf/AD7zf9/jTTdaZ2tpv+/xryH+1dQ/5/rn/v8AN/jR/auof8/1z/3+b/Gp5p+X/gKJ/wBV5/8AP2P/AILX+Z66bvTv+fSb/v8AGm/a9P8A+fWb/v8AGvJP7V1D/n+uf+/zf40f2rqH/P8AXP8A3+b/ABqff8v/AAFE/wCq1T/n9H/wWv8AM9a+12H/AD7Tf9/jSG5sSMfZpf8Av6a8m/tXUP8An+uf+/zf40f2rqH/AD/XP/f5v8aVp+X/AICif9VZv/l8v/Ba/wAz25PFrxRLHHBtVAFUZ6AUp8YT/wDPM/nXiH9q6h/z/XP/AH+b/Gj+1dQ/5/rn/v8AN/jXX9cxlre0/A7v7Fx9rLF/+SL/AOSPbT4uuP7p/OmnxbdHoCPxrxT+1dQ/5/rn/v8AN/jR/auof8/1z/3+b/Gl9bxn/P1k/wBiY9/8xj/8B/8Atj3Wx8WkFvtQz6ZNXP8AhMIP7g/Ovn7+1dQ/5/rn/v8AN/jR/auof8/1z/3+b/GuiGZYyEeXnv8AI6qeWY+nHl+s3/7c/wDtj6APjGD/AJ5j86YfGUXaIfnXgX9q6h/z/XP/AH+b/Gj+1dQ/5/rn/v8AN/jVf2pjf5/wK/s7MP8AoJ/8k/8Atj3s+M0/54frWVfapp99dNcTWr+YwAJWQjOK8Z/tXUP+f65/7/N/jR/auof8/wBc/wDf5v8AGsKuMxNaPLUkmvNI56+S4zER5KuITXnTX/yR679q03/n1m/7/Gg3mnf8+k3/AH+NeRf2rqH/AD/XP/f5v8aP7V1D/n+uf+/zf41yXm+3/gKOH/VafStH/wAFr/M9bN3p/a1m/wC/xpPtVj/z7Tf9/jXkv9q6h/z/AFz/AN/m/wAaP7V1D/n+uf8Av83+NL3/AC/8BQv9Van/AD+X/gtf5nrP2qy/595v+/ppDc2faCX/AL+mvJ/7V1D/AJ/rn/v83+NH9q6h/wA/1z/3+b/Gp5Zd19yJ/wBVJ/8AP9f+C1/mer/abX/njL/38NJ9otv+eMn/AH8NeU/2rqH/AD/XP/f5v8aP7V1D/n+uf+/zf40uSXdfchf6pT/5/r/wBf8AyR6r9ot/+ecn/fw1oRSaOYl8xJt+Of3prxr+1dQ/5/rn/v8AN/jR/auof8/1z/3+b/GtKfNB30fqkaUuFZU3d1U/Wmv/AJI9nMui9km/7/GmGbR+0U3/AH+NeN/2rqH/AD/XP/f5v8aP7V1D/n+uf+/zf41p7R/yx/8AAUbf6tS/5+R/8Fr/AOSPdbLxLaadai3tbfCAk8tk5NTnxon/AD7/AK14H/auof8AP9c/9/m/xo/tXUP+f65/7/N/jXVHMMZCKjGaSXkjshlOOhFQhiUkv7i/+SPej42X/n2/Wm/8JvjpaZ/4FXg/9q6h/wA/1z/3+b/Gj+1dQ/5/rn/v83+NP+0sd/z8/BB/ZeY/9Bf/AJIv8z3f/hOG7WuP+BU0+NmP/Lt+teFf2rqH/P8AXP8A3+b/ABo/tXUP+f65/wC/zf41P9oY7/n7+CJ/snMX/wAxf/ki/wAz3E+MpCeIP1pD4wkP/LH9a8P/ALV1D/n+uf8Av83+NH9q6h/z/XP/AH+b/Gp+vY3/AJ+/gS8nzB/8xf8A5Iv/AJI9t/4S6b/nmfzoPi647IR+NeJf2rqH/P8AXP8A3+b/ABo/tXUP+f65/wC/zf41P1zG/wDP1/cT/YuYP/mMf/gP/wBse1/8Jbdeh/OpLfxbN5y+cDs7814h/auof8/1z/3+b/Gj+1dQ/wCf65/7/N/jQsZjE0/aMUckx6kn9bf/AID/APbHv58WW46KPzpP+EvgH/LMfnXgP9q6h/z/AFz/AN/m/wAaP7V1D/n+uf8Av83+NdX9qYz+Zfcdv9n4/wD6CV/4B/8AbHv3/CYxDpEPzph8ZR/88P1rwT+1dQ/5/rn/AL/N/jR/auof8/1z/wB/m/xqf7Txv8/4EPLcw/6Cv/JF/wDJHvJ8Zp2t/wBaT/hNQOlt+teD/wBq6h/z/XP/AH+b/Gj+1dQ/5/rn/v8AN/jU/wBpY7/n5+CJ/szMf+gv/wAkX/yR7t/wmp7Wv/j1J/wmhJ5tf1rwr+1dQ/5/rn/v83+NH9q6h/z/AFz/AN/m/wAan+0Md/z8/BE/2VmL/wCYv/yRf5nuZ8Zvn5bfH40w+MJCf9T+teH/ANq6h/z/AFz/AN/m/wAaP7V1D/n+uf8Av83+NT9fxr/5e/giXlGYv/mL/wDJF/8AJHtzeLpD0hx+NJ/wlswHEZ/OvEv7V1D/AJ/rn/v83+NH9q6h/wA/1z/3+b/Gl9dxv/P38CHkuYP/AJjH/wCAf/bHtp8XXGPun86b/wAJbddgfzrxT+1dQ/5/rn/v83+NH9q6h/z/AFz/AN/m/wAan63jP+frJ/sPHv8A5jH/AOA//bHvFl4uAiP2kZbPGTVg+L4OyD86+f8A+1dQ/wCf65/7/N/jR/auof8AP9c/9/m/xrohmWMjFR5/wOuGWY+EVH6z/wCSf/bHvx8Xw/8APMfnTf8AhMY/+eP614H/AGrqH/P9c/8Af5v8aP7V1D/n+uf+/wA3+NP+1Mb/AD/gP+zsw/6Cf/JP/tj3seMo16QfrSnxuv8Az7frXgf9q6h/z/XP/f5v8aP7V1D/AJ/rn/v83+NL+0sd/wA/PwRLy3Mf+gr/AMkX/wAke9HxwO1r/wCPVG3jYn/l1/8AHq8J/tXUP+f65/7/ADf40f2rqH/P9c/9/m/xqf7Rx3/Pz8ES8rzJ/wDMX/5Iv8z3QeNGH/Lt+tIfGch/5YfrXhn9q6h/z/XP/f5v8aP7V1D/AJ/rn/v83+NT9fxz/wCXv4Ij+ycxf/MX/wCSL/5I9wPjGQ9IcfjTT4umJ/1Z/OvEf7V1D/n+uf8Av83+NH9q6h/z/XP/AH+b/Gp+vY1/8vfwJ/sfMP8AoM/8kX/yR7X/AMJZP/cP50N4suG/hP514p/auof8/wBc/wDf5v8AGj+1dQ/5/rn/AL/N/jU/XMY/+XrJeSY9/wDMY/8AwH/7Y9rXxZcgjg4z61pjxdDtGVGcc814D/auof8AP9c/9/m/xo/tXUP+f65/7/N/jWtLH4ynf37+qNqOU4+lf/ar+sP/ALY9+/4S+H+4PzoPjGIDiMfnXgP9q6h/z/XP/f5v8aP7V1D/AJ/rn/v83+Na/wBqY3+f8Db+z8w/6CV/4B/9se9nxjHniH9aT/hM0/54frXgv9q6h/z/AFz/AN/m/wAaP7V1D/n+uf8Av83+NT/aeN/n/BE/2bmP/QV/5Iv/AJI96/4TYD/l2/Wk/wCE4x0tP/Hq8G/tXUP+f65/7/N/jR/auof8/wBc/wDf5v8AGp/tLHf8/PwRLyzMv+gv/wAkX+Z7ufHBPS1/8epP+E3b/n3/APHq8J/tO/8A+f65/wC/zf40n9pXx63tx/39b/Gj6/jn/wAvfwQv7JzF/wDMZ/5Iv/kj3Y+Nn7Qf+PUw+NJT/wAsv1rwv+0b3/n8uP8Av63+NJ9vvP8An7n/AO/hpfXMa/8Al7+Af2LmD/5jP/JF/wDJHuR8ZTf3P1pp8Y3H939a8P8At12f+Xqb/v4aT7Zdf8/M3/fw0fWcY/8Al6/uF/YOYP8A5jH/AOAf/bHuB8YXPYfrU9n4xkEp+0/cx3NeD/a7j/n4l/77NH2qf/nvJ/32auGIxkZKXtfwLhw/j4yUvrjf/bn/ANsfQreMrfsB+dM/4TKD+6Pzr58+0Tf89pP++jSefL/z1f8A76Ndf1/GP7f4Hd/Y+Pf/ADFL/wAA/wDtj6C/4TKH/nmP++qb/wAJnEP+WQ/76r5+82T/AJ6N/wB9UeY/99vzpfXMa/8Al5+Af2JmD/5i/wDyRf8AyR7+3jVO0Q/76pv/AAmwH/LEf99V4DuY9WP50mT60fWcc/8Al7+CF/YOYv8A5jP/ACmv/kj2PWNYGqXAlYBMDGM1N4fS3kujNLMqiI5we9eK0qsVztJGeuDXPQwrlilXqy5ne+1jlw3BLnjViK+I5ne/wW/9uPQvjL4tEFvDokQAaZVnL5/hOQBj86534b+FG1+zvHgvEga3CgZTduLZx3GBxWRLqV9OVM97cSFVCqXlY4A6AZPSpLfWdUtAwtdSvIA33vLnZc/ka+2+sqU7uOh7f9izpYblp1bS72v113Z5v4gvWvdRmeRslSV/Kuw0r/kDWX/Xun/oIq+bmcnJnkJ/3zUZJJJJyT1Jrx8wqc8Y6H6NwjhPq9eo+a90unmf/9k=)

*Hình 6.2 - 14 Không khoanh được vùng kí tự*

Ở ảnh 6.2 - 14 chỗ số 0 bị dính con ốc dẫn đến không thể khoanh vùng được, Tuy nhiên ở chữ F mặc dù vẫn dính con ốc trong ảnh cắt ra để nhận diện, mô hình KNN vẫn cho ra đáp án đúng.

# KẾT LUẬN VÀ HƯỚNG PHÁT TRIỂN

## Kết luận

Dựa trên kết quả thực nghiệm, phương pháp nhận diện biển số xe sử dụng **xử lý ảnh** và thuật toán **KNN** mang lại một số ưu điểm và hạn chế đáng chú ý:

* **Ưu điểm**:
  + **Dễ triển khai**: KNN là thuật toán cơ bản, dễ cài đặt, không đòi hỏi cấu hình phức tạp.
  + **Nhẹ và hiệu quả trên máy tính cấu hình thấp**: Phương pháp này hoạt động mượt mà ngay cả trên các thiết bị có hiệu năng không cao, phù hợp cho người mới bắt đầu hoặc các dự án nhỏ.
  + **Học tập và nghiên cứu**: Đây là công cụ hữu ích để sinh viên và người mới làm quen với lĩnh vực **xử lý ảnh** hoặc **AI**, cung cấp nền tảng cơ bản trước khi tiến xa hơn.
* **Hạn chế**:
  + **Hiệu suất nhận diện chưa cao**:
    - KNN phụ thuộc vào số lượng và chất lượng của dữ liệu huấn luyện. Khi tập dữ liệu lớn, thời gian xử lý tăng lên đáng kể.
    - Nhận diện kém trong các trường hợp như:
      * Biển số bị **phản chiếu ánh sáng** hoặc bị **chói sáng** từ môi trường.
      * Biển số có kí tự không rõ ràng hoặc bị mờ.
      * Các trường hợp đặc biệt với biển số xe ô tô, do **nền phản quang** xung quanh.
  + **Đòi hỏi điều kiện lý tưởng**:
    - Môi trường cần được kiểm soát tốt (ánh sáng đồng đều, không bị lóe sáng).
    - Phương pháp này vẫn cần sự can thiệp và giám sát từ con người, chưa thể hoạt động hoàn toàn tự động.

## Hướng phát triển

1. **Cải tiến thuật toán nhận diện**:
   1. Thay thế KNN bằng các thuật toán mạnh mẽ và hiện đại hơn:
      1. **CNN (Convolutional Neural Networks)**: Hiệu quả cao trong trích xuất và phân loại đặc trưng từ hình ảnh.
      2. **SVM (Support Vector Machine)**: Tối ưu cho các bài toán phân loại phức tạp.
      3. **YOLO (You Only Look Once)**: Thư viện tiên tiến với khả năng nhận diện đối tượng nhanh và chính xác.
2. **Tăng cường phần cứng**:
   1. Sử dụng **camera chuyên dụng** cho nhận diện biển số:
      1. Có khả năng hoạt động tốt trong điều kiện ánh sáng yếu, sương mù hoặc chói sáng mạnh.
      2. Tăng độ rõ nét và giảm nhiễu từ các yếu tố môi trường.
3. **Nâng cao phương pháp xử lý ảnh**:
   1. Áp dụng các thuật toán xác định vị trí biển số chính xác hơn như:
      1. **Biến đổi Hough**: Nhận diện đường thẳng giúp cải thiện việc xác định biên giới biển số.
      2. Nhận diện dựa trên **màu sắc đặc trưng** hoặc **các đặc trưng hình dạng**.
      3. Các phương pháp giảm **di ảnh** cho xe di chuyển nhanh, giúp tăng độ chính xác nhận diện.
4. **Ứng dụng trong hệ thống lớn hơn**:
   1. Kết hợp nhận diện biển số với các hệ thống quản lý và giám sát:
      1. **Quản lý bãi xe**: Tự động kiểm soát ra/vào.
      2. **Giám sát giao thông**: Hỗ trợ phát hiện xe vi phạm, theo dõi phương tiện bị mất cắp.
      3. **Hệ thống quản lý đô thị thông minh**: Kết hợp với dữ liệu khác để nâng cao hiệu quả quản lý.