**Removing Interference Lines**

**Grayscale and Binarization**

This step is mainly for convenience in subsequent processing. Each pixel in the image is assigned only two values: either **255 (white)** or **0 (black)**. One value represents information elements (foreground), while the other represents the background.

**Character Segmentation**

**CFS (Connected Component Labeling)**

The idea behind character segmentation is:

1. Find a black pixel.
2. Traverse all neighboring black pixels until all connected black pixels are found.
3. Identify the **topmost, bottommost, leftmost, and rightmost** pixels in this connected region.
4. These four boundary points define a **single character**.
5. Continue scanning for the next black pixel and repeat the process.
6. Use the boundary points to segment each character.

A black and green rectangular numbers

AI-generated content may be incorrect.

The red points in the image represent the four boundary points of each detected character. The segmentation is performed based on these points.

However, in some cases, characters may be **stuck together** (e.g., "m2" being recognized as one character). To address this:

* Check the **width** of each detected character.
* If a character is **too wide**, assume it consists of two merged characters.
* Split it **in the middle** to separate them.

**Drop-Fall Algorithm**

In CAPTCHA recognition, the "drop-fall" algorithm refers to a **pixel-by-pixel tracking method** that follows edges, similar to how a water droplet moves along the surface of an object.

* This algorithm helps **accurately segment characters**, especially when characters are stuck together.

**Character Normalization**

**Rotation Correction**

* The **getRotationMatrix2D** function calculates the rotation matrix.
* The **warpAffine** function applies the rotation transformation.
* This ensures characters are **aligned properly** before further processing.

**Size Normalization**

* Resize all CAPTCHA characters to a **fixed size** to maintain consistency.