The entire code repository can be found at https://github.com/dgsaf/comp3007_assignment.

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2.1 Problem Analysis

To detect the characters (digits and arrows), we utilise the technique of Maximally Stable Extremal Regions (MSER). We suggest that this technique is suitable for our purpose, as the characters are uniformly white and contrast well against the surrounding uniformly black area of the signs. Hence, these characters should form regions which are very stable under thresholding, when compared with their local context. Furthermore, this technique should be fairly robust to the presence of shadows and other variations in illumination.

2.2 Technique

Image

We define an image I, with n channels and of width w and height h, to be a mapping

$$I : D \to S : (x, y) \mapsto I(x, y) = \big(I_1(x, y), \ldots, I_n(x, y)\big), \tag{1}$$

where the domain $D \subset \mathbb{N}^2$ is of the form $D = \{0, \ldots, w - 1\} \times \{0, \ldots, h - 1\}$, and where the codomain S is in general of the form $S \subset \mathbb{R}^n$.

Thresholded Image

Suppose $I : D \to S \subset \mathbb{R}$ is a single-channel image. For each $t \in S$, we define the Boolean-valued image I_t to be of the form

$$I_t : D \to \mathbb{B} : (x, y) \mapsto \begin{cases} 0 & \text{if} \quad I(x, y) \leq t \\ 1 & \text{if} \quad I(x, y) > t \end{cases}, \tag{2}$$

and we say that I_t is a thresholded image.

Connectedness

Suppose D is the domain of an image. An adjacency relation A on D is a Boolean-valued mapping

$$A : D \times D \to \mathbb{B} : (p, q) \mapsto A(p, q), \tag{3}$$

which indicates if the two points of the domain are considered to be adjacent. For any $p \in D$, we may define the neighbourhood $N(p)$ of p to be the set of all points which are adjacent to it; that is,

$$N(p) = \{q \in D \mid A(p, q)\}. \tag{4}$$

For any $p, q \in D$, we say that p and q are connected if there exists a finite sequence $(\rho_k)_{1 \leq k \leq n}$ in D such that

$$A(p, \rho_1) \wedge A(\rho_1, \rho_2) \wedge \cdots \wedge A(\rho_{n-1}, \rho_n) \wedge A(\rho_n, q) = 1. \tag{5}$$

In the case where the adjacency relation A is symmetric, then connectedness defines an equivalency relation; whence we may write, for any connected $p, q \in D$ that $p \sim q$.

Region

We define image regions, for the case of a single channel image, in the theme of the MSER approach. Suppose $I : D \to S \subset \mathbb{R}$ is a single-channel image, and for all $t \in S$, let I_t be its thresholded image. Suppose $A : D \times D \to \mathbb{B}$ is the (symmetric) adjacency relation associated with either the Von Neumann neighbourhood (4-connectivity) or the Moore neighbourhood (8-connectivity). For all $t \in S$, we define a new adjacency relation $A_t : D \times D \to \mathbb{B}$ by

$$A_t(p, q) = A(p, q) \wedge \left[I_t(p) \iff I_t(q)\right], \tag{6}$$

that is, two points $p, q \in D$ are considered adjacent by A_t if they are geometrically adjacent by A and map to equivalent values in the thresholded image I_t.
For all $t \in S$, we define an image region $R \subset D$ to be a subset of the image domain that is connected by the adjacency relation A_t; that is, for all $p, q \in R$, we have that $p \sim q$ by A_t.

2.3 Task 1

2.4 Task 2

3 Validation Performance

3.1 Task 1

3.2 Task 2

4 Conclusion

A Source Code