A collaborative study between medicine, engineering, and informatics: a novel approach for early detection of biliary atresia

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1 Background and Motivation

Biliary atresia (BA) is a disease suffered by infants. This study introduces a new method based on artificial-intelligence techniques to discriminate between BA and non-BA stool samples. As a part of a prospective-cohort study, we have developed a free iPhone mobile application for early detection of BA (Hoshino, et al., 2017). Thus far, stool-color cards have been used by families to detect BA; however, accurate detection is difficult with the mere information on the card. Therefore, our existing mobile application is useful as a screening support tool. Herein, we propose a filter to discriminate between the stool and the baby diaper and evaluate the performance of a classifier using this filter.

2 Proposed Methods

We denote the training observations of the BA, non-BA, and diaper groups as \( x_i^{BA}, x_i^{noBA}, \) and \( x_i^D \), respectively. Here \( i \) represents the index for observation of each group. In addition, we assume that the number of dimensions of each observation is \( p \) and that each observation is composed of HSV (hue, saturation, and value) values of a baby-stool image photographed using our mobile application. First, we develop an optimal classifier to discriminate between the stool and diaper groups. Second, we equivalently divide a test image into \( m \) regions. Third, we apply the classifier to each region \( (x_{i,j}^H, x_{i,j}^S, x_{i,j}^V) \in \mathbb{R}^{1 \times p} \) where \( j \) ranges from 1 to \( m \) and \( x_{i,j}^H, x_{i,j}^S, \) and \( x_{i,j}^V \) are replicated vectors of H, S, and V on the \( j \)-th region, respectively. To select only the stool parts of the image, we choose \( \ell (1 \leq \ell \leq m) \) regions based on similarities between \( (x_{i,j}^H, x_{i,j}^S, x_{i,j}^V) \) and \( x_i^{BA}, x_i^{noBA}, \) and \( x_i^D \). Finally, we compose a quasi-test observation with the selected \( \ell \) regions and apply our existing detection method to the quasi-test observation.

3 Results and Conclusions

With an additional 60 test images, we compared the results of the proposed and existing methods. We determined the ratio of photographs that were accurately distinguished above a similarity value of 0.7. As a result, through a two-sample test of the equality of proportions, we found that the accuracy proportion of BA obtained using the new method was significantly higher than that based on the existing method (\( P < 0.05 \)). In this study, we proposed an extended method from a point of view of filter and confirmed its performance. We are collecting a considerable amount of stool-image data in real time. In future, we plan to apply our new approach to a huge test dataset.

References