# 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 $\boldsymbol{x}_i^{BA}$, $\boldsymbol{x}_i^{noBA}$, and $\boldsymbol{x}_i^{D}$, 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 $(\boldsymbol{x}_{i,j}^{H\,T}, \boldsymbol{x}_{i,j}^{S\,T}, \boldsymbol{x}_{i,j}^{V\,T}) \in \mathbb{R}^{1\times p}$ where $j$ ranges from 1 to $m$ and $\boldsymbol{x}_{i,j}^{H\,T}$, $\boldsymbol{x}_{i,j}^{S\,T}$, and $\boldsymbol{x}_{i,j}^{V\,T}$ 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 $(\boldsymbol{x}_{i,j}^{H\,T}, \boldsymbol{x}_{i,j}^{S\,T}, \boldsymbol{x}_{i,j}^{V\,T})$ and $\boldsymbol{x}_i^{BA}$s, $\boldsymbol{x}_i^{noBA}$s, and $\boldsymbol{x}_i^{D}$s. 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

Hoshino, E., Hayashi, K., Suzuki, M., Obatake, M., Urayama, K., Nakano, S., Taura, Y., Nio, M., and Takahashi, O., An iPhone application using a novel stool color detection algorithm for biliary atresia screening, 7th International Sendai Symposium on Biliary Atresia, May, 2017, Sendai, Japan.