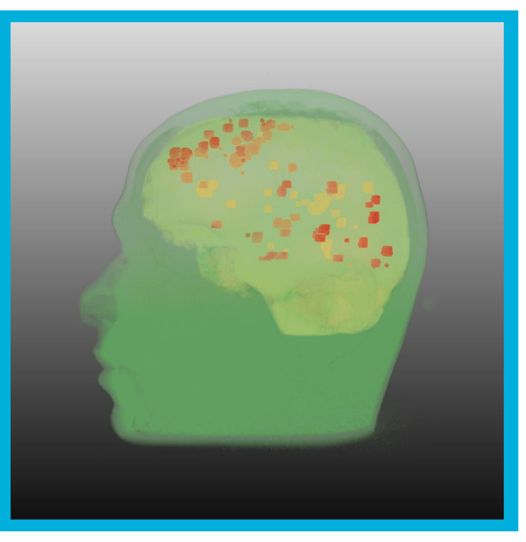
Computer Aided Detection of Brain Micro-Bleeds in Traumatic Brain Injury



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Introduction

- Brain Micro-Bleeds (BMBs) are hemosiderin deposits in the brain that are caused by leakage of red blood cells from small blood vessels.
- Traumatic Brain Injury (TBI) leads to BMBs, but it is unknown whether BMBs have predictive value for prognosis.
- Computer Aided Detection (CAD) of BMBs is needed because manual annotation is a time consuming task where BMBs are easily overlooked.

Objective
Design a Computer Aided Detection system that automatically detects Brain Micro-bleeds in Traumatic Brain Injury patients, to be able to investigate the predictive value of micro-bleeds.

Material and Methods

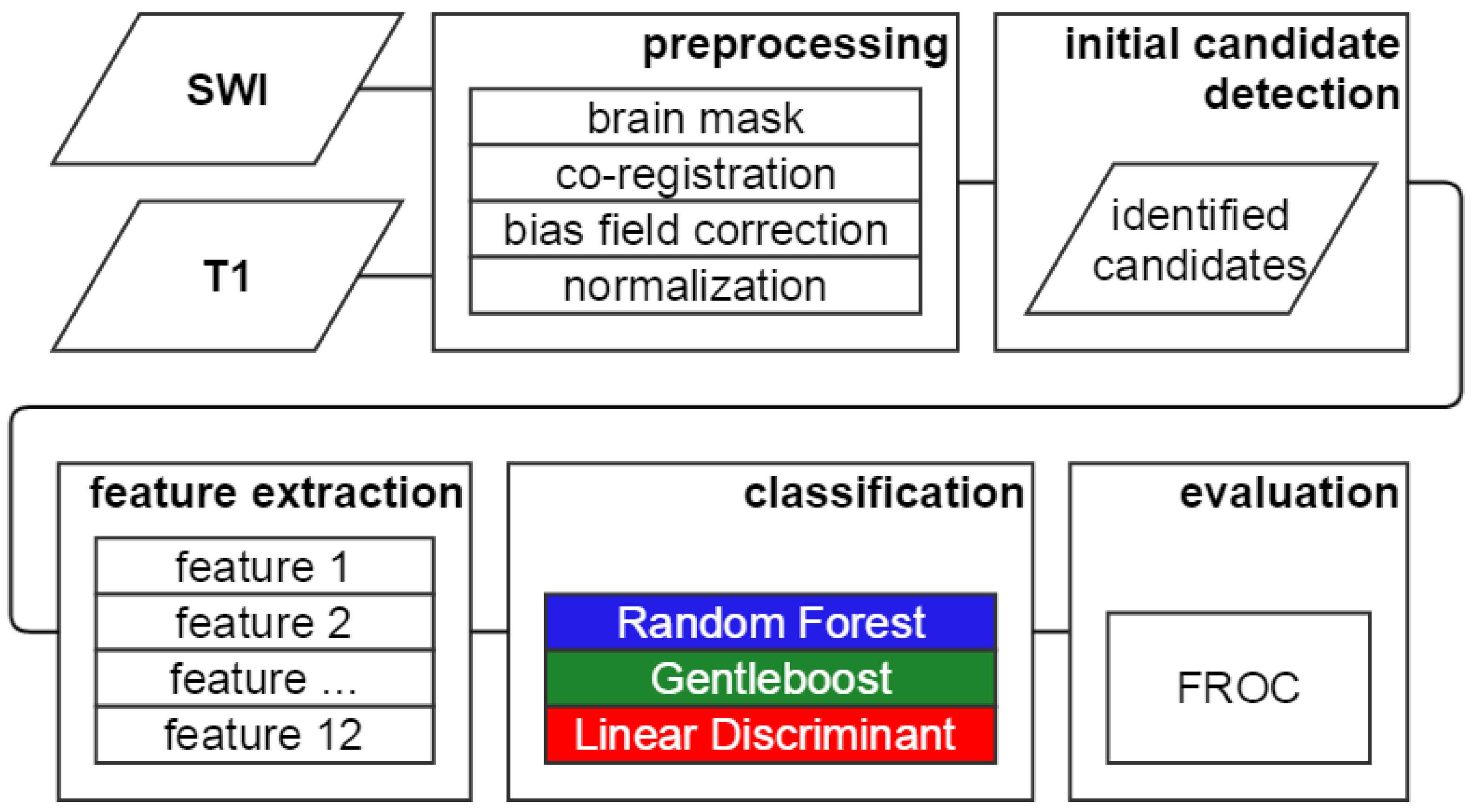

Figure 1. Schematic overview of the CAD system.

- Susceptibility Weighted Imaging (SWI) of 33 TBI patients and 18 healthy subjects were used for the CAD-system. The BMBs were annotated by one expert, using the guidelines of MARS.
- T1 weighed MR imaging (T1) contains additional anatomical information, like the gray and white matter boundary.
- The preprocessing steps are shown in Figure 1.
- Initial candidate detection was performed using the local minima and an intensity threshold in the SWI scan.
- Feature extraction was based on intensity and local shape. The intensity features were computed on both SWI and T1 scan. The local shape feature were solemnly calculated on the SWI scan, since BMBs are best visible in this sequence.
- Classification was done using three classifiers, the Random Forest-, Gentleboost- and Linear Discriminant Classifier. The positive samples were those inside the annotations and the negative samples were those inside the healthy subjects.
- During evaluation the performance of the classifiers was tested using Free-response Receiver Operating Characteristic (FROC) analysis.

Results

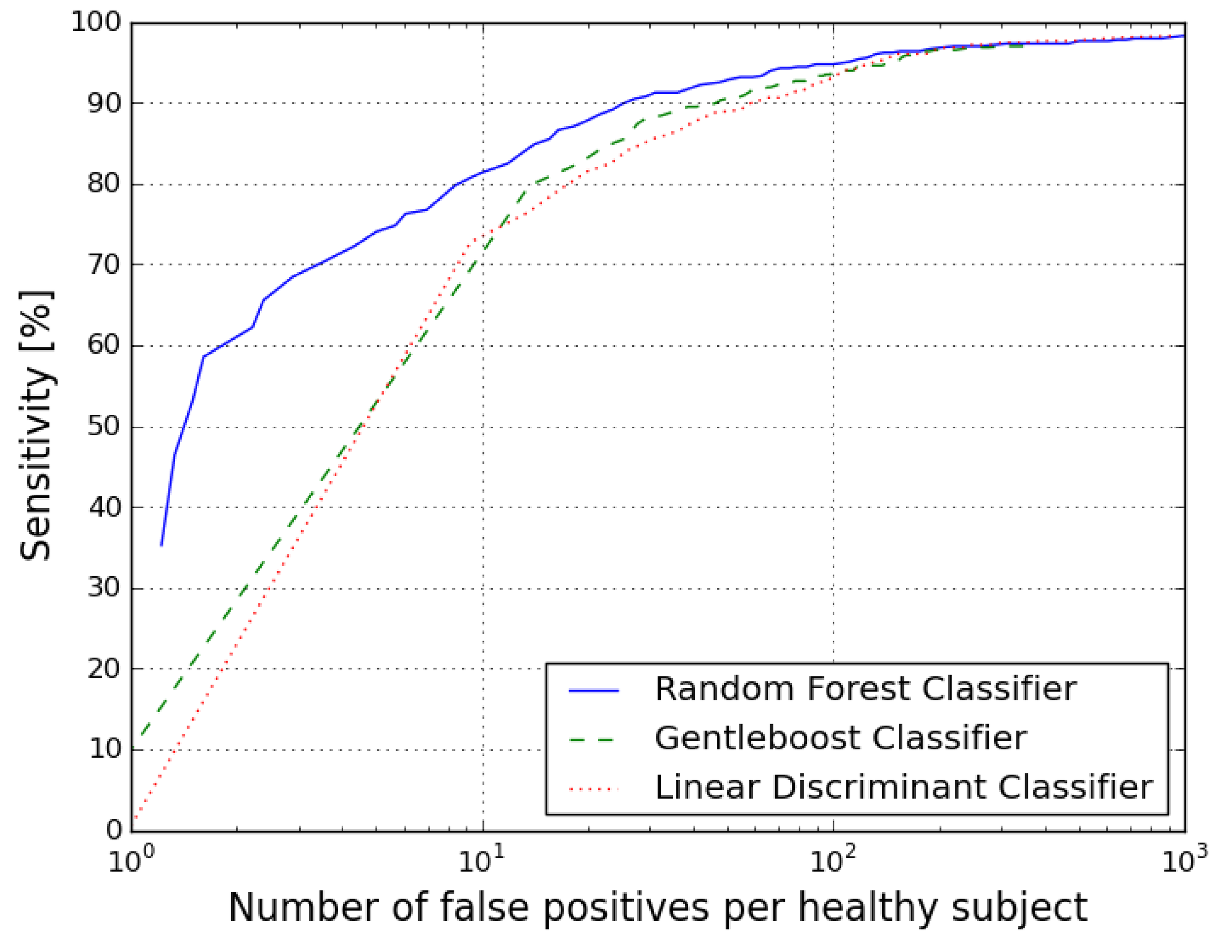

Figure 2. FROC performance for different classifiers.

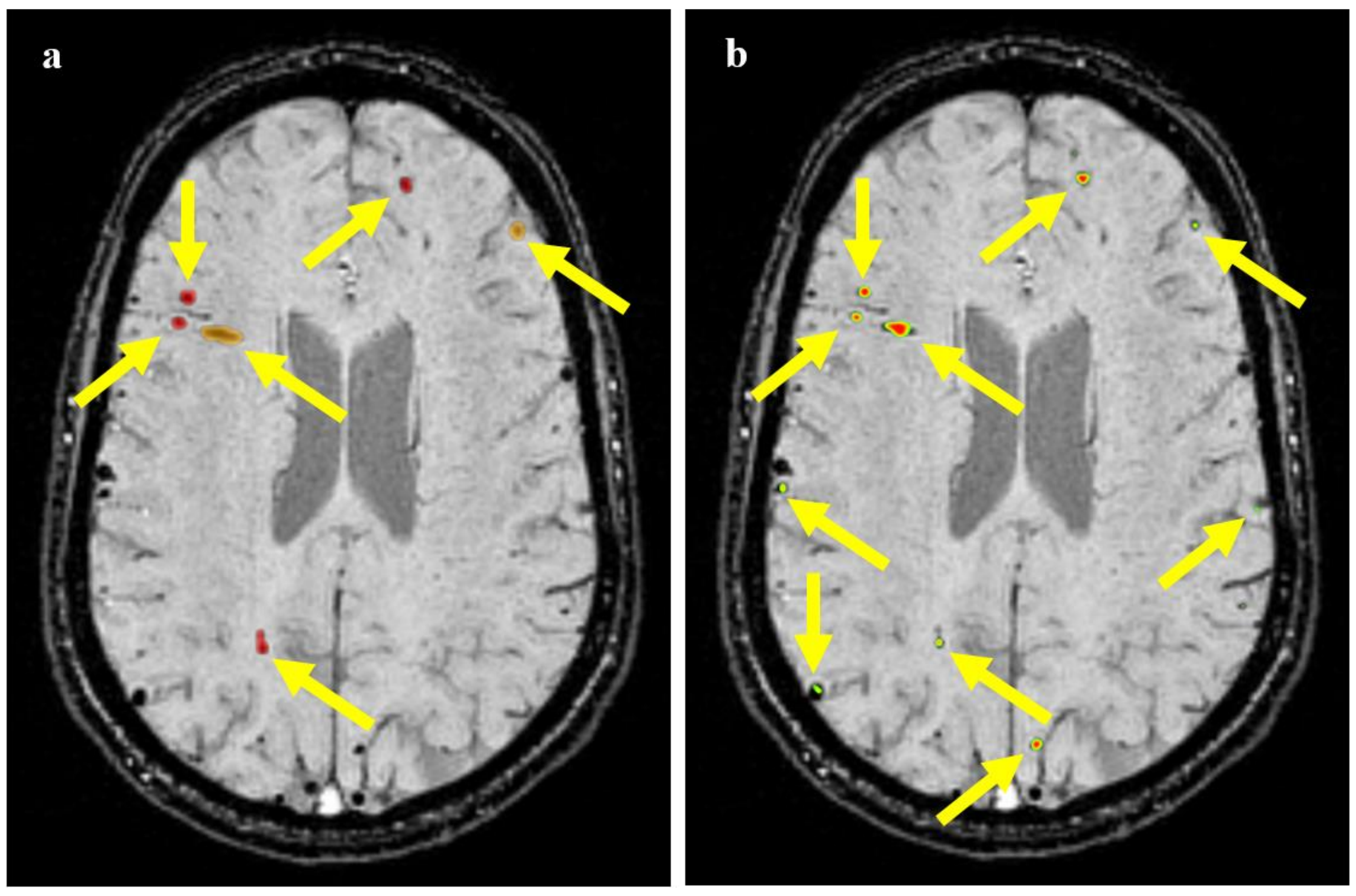

Figure 3. a) Expert annotations, in red the definite BMBs, in orange the possible BMBs; b) Likelihood of voxel detection, in red represents a high likelihood of being a BMB.

Discussion

- The number of false positives is computed from the healthy subjects, because BMBs could be overlooked by the expert. The false positives in the healthy subjects are mostly blood vessels, because they have similar appearance as BMBs.
- Manual evaluation of the CAD-system result for the TBI patient population will be part of future work. At this moment we assume that the number of false positives will be in the same range as in the healthy subjects.

Conclusion
With a sensitivity of 90% and 1.3 false positives per BMB, our CAD system shows superior results compared to state-of-the-art BMB detection algorithms (developed for non-trauma patients).

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