Study on the Performance of an Artificial Intelligence System for Image Based Analysis of Peripheral Blood Smears

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Abstract
In this study, we evaluate Shonit™, an artificial intelligence (AI) system for automated analysis of images captured from peripheral blood smears, consisting of an automated digital microscope and a cloud based analysis platform. Shonit™'s performance in classification of WBCs was evaluated by comparing Shonit™'s results with haematologyanalysers and manual microscopy for manually stained smears. The study was carried out over 100 samples. The cases included both normal and abnormal samples, wherein the abnormal cases were from patients with one or more quantitative or qualitative flagging. All the smears were created using Hemaprep auto-smearer and stained using May Grunwald Giemsa stain. They were scanned and analysed by Shonit™ for WBC differentials under 40X magnification.WBC morphological classification by Shonit™ was verified by an experienced haemato-pathologist. Quantitative parameters were analysed by computing the mean absolute difference of the WBC DC values between Shonit™ and Sysmex XN3000, between Shonit™ and manual microscopy & between Shonit™ and Horiba ES 60.

The mean absolute difference between WBC differential values of manual microscopy and Shonit™ were 7.67%, 5.93%, 4.58%, 2.69%, 0.44% for neutrophil, lymphocyte, monocyte, eosinophil and basophil respectively. The mean absolute difference between WBC differential values of Sysmex XN3000 and Shonit™ were 8.73%, 5.55%, 3.63%, 2.12%, 0.45% for neutrophil, lymphocyte, monocyte, eosinophil and basophil respectively. Shonit™ has proven to be effective in locating and examining WBCs. It saves time, accelerates the turnaround-time and increases productivity of pathologists. It has helped to overcome the time-consuming effort associated with traditional microscopy.

Keywords: Peripheralblood Smears, Image Analysis, Artificial Intelligence, Shonit™

Introduction
Shonit™ is a system for automated analysis of peripheral blood smears. The solution is powered by advancements in artificial intelligence, image processing, and cloud computing. Shonit™ can be used for morphological analysis of leukocytes, erythrocytes, and platelets. It provides differential count of leukocytes, total count of leukocytes, erythrocytes and platelets and analysis of aniso- poikilocytosis. Shonit™ also reports key volumetric and non-volumetric indices for erythrocytes. In this study, the performance of Shonit™ in reporting 5-part WBC differentials was evaluated by comparing Shonit™'s results with haematology analysers and manual microscopy.

Objective
To clinically validate the efficacy and accuracy of WBC differentials produced by Shonit™ by comparison with existing state-of-the-art haematology analyser and manual microscopy.

Material and Methods
The study was carried out on over 100 samples. The cases included both normal and abnormal samples, wherein the abnormal cases were from patients with one or more quantitative or qualitative flagging. All the smears were created using Hemaprep auto-smearer and stained using May Grunwald Giemsa stain. They were scanned by the Shonit™ automated digital microscope at 400 X magnifications and analysed by the cloud based AI platform Shonit™ for WBC differentials under 400X magnification.
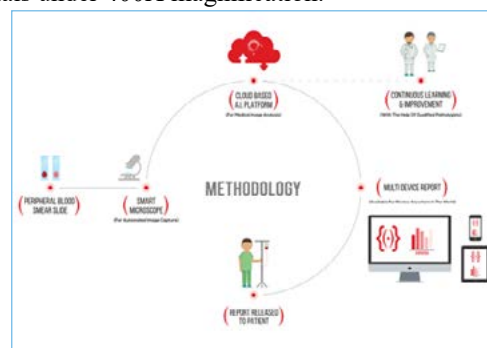
Analysis

Over 100 samples were analysed by Shonit™, Sysmex 5-part XN3000 and Horiba 3-partES 60 analyser, for a comparative analysis between the three. Manual microscopy results were obtained in order to establish the benchmark for analysis. WBC morphological classification by Shonit™was verified by an experienced haemato-pathologist.

Quantitative parameters were analysed by computing the mean absolute difference of the WBC differential values between Shonit™, Sysmex XN3000 5-part haematologyanalyser, Horiba ES 60 3-part haematology analyser and manual microscopy. The results were compared as per standard statistical methods and are illustrated in the table and scatter plots given below.

Results

The results are shown below using statistical techniques and scatter plots. The neutrophil,
eosinophil, and basophil differentials provided by Shonit™ and the 5-part haematology analyser were clubbed into the granulocytes bucket for a comparative analysis between Shonit™, 3-part analyser and5-Part analyser.
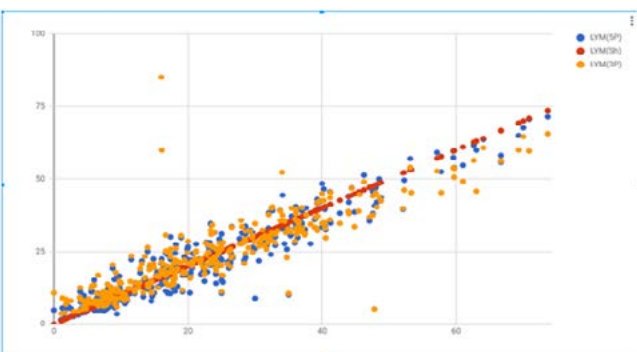Mean Absolute difference analysis:

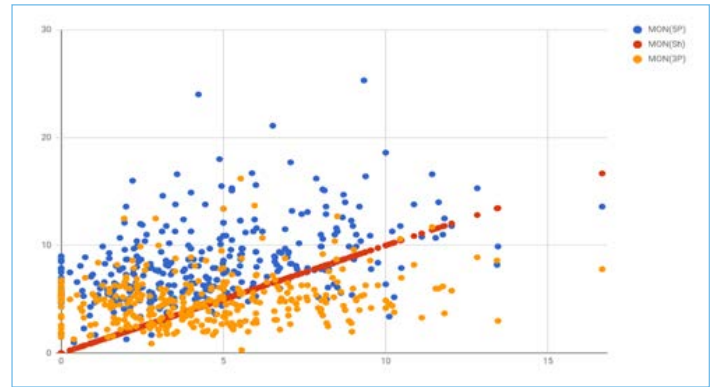| Comparison Type	Shonit™v. 5 Part Analyser	Shonit™ v. Manual Microscopy
Neutrophil	8.73%	7.67%
Lymphocyte	5.55%	5.93%
Monocyte	3.63%	4.58%
Eosinophil	2.12%	2.69%
Basophil	0.45%	0.44%

Shonit™ v. 5 Part Analyser v. 3 PartAnalyser: Granulocytes
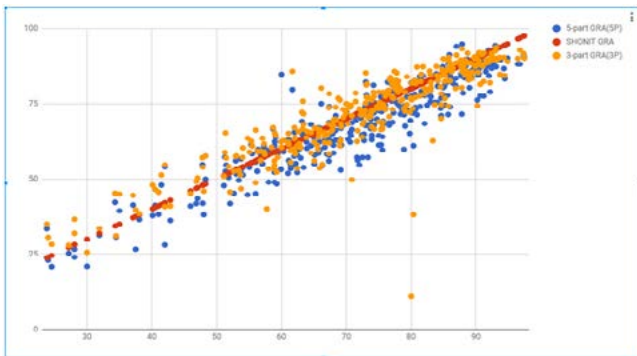
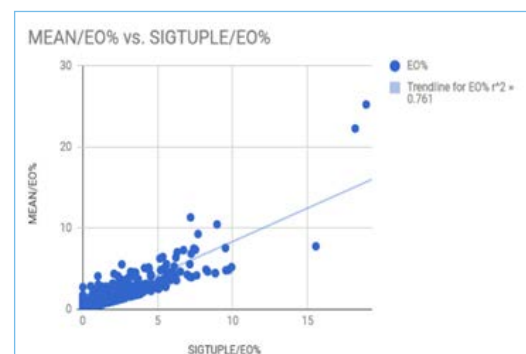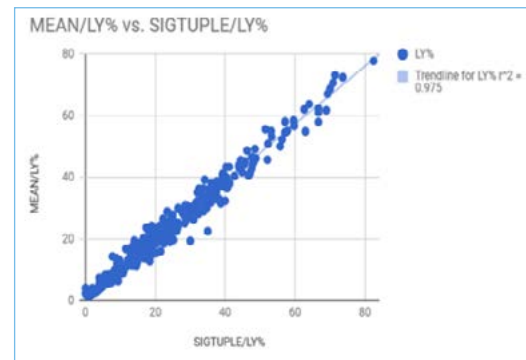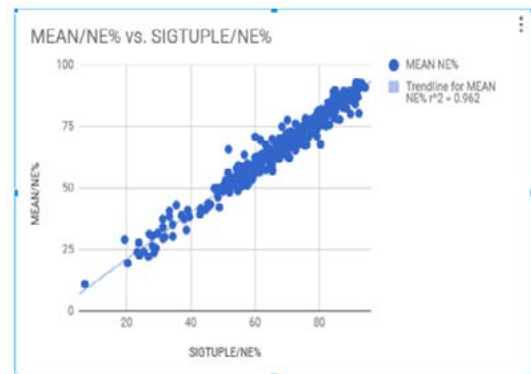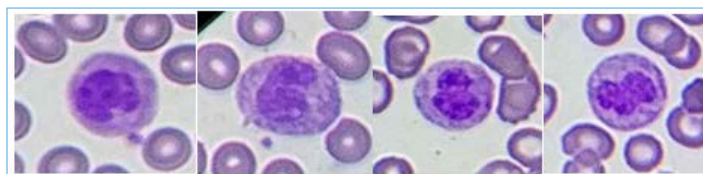### Shonit™ v. 5 Part Analyser v. 3 Part Analyser: Lymphocytes
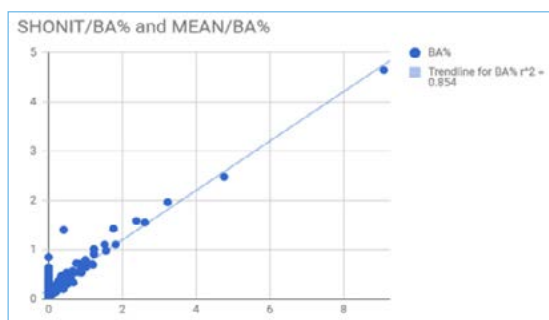

Shonit™ v. 5 Part Analyser v. 3 Part Analyser: Monocytes

Correlation analysis between ShonitTMDC and 5-Part DC

The r2 coefficient mean of observations between ShonitTM and 5-Part haematology analyser for neutrophils, lymphocyte, monocyte, eosinophil, and basophil were 0.96, 0.97, 0.74, 0.76 and 0.85 respectively. The correlation plots for the same are shown below.
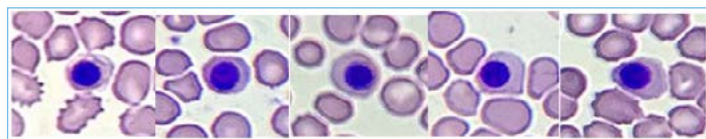
SHONIT/BA% and MEAN/BA%

Case studies

Shonit™ has proven to be more effective than the 5-part haematology analyser in the following cases.

- **Monocyte Differentials**: A set of cases were selected where the absolute difference between the Monocyte differentials reported by Shonit™ and the 5-Part haematology analyser was greater than 10%. Manual differential counts were obtained for the mentioned cases. The following table entails the details of the analysis for these cases:

Type of Case	Number of Cases
Cases where Shonit™ correlated with Manual Microscopy	11
Cases with staining Problem	2
Cases with degenerated cells	1

For cases where there was a discrepancy between monocyte differentials reported by Shonit™ and the 5-Part haematology analyser, values reported by Shonit™ correlated better with the manual differential counts, proving that monocyte identification and enumeration was better than the 5-Part Haematology Analyser.

- **Leukopenia Cases**: Manual differential counts were obtained for cases of Leukopenia and it was observed that Shonit™ has reported more accurate results in comparison to the 5-part haematology analyser or manual microscopy.
- **Flagging Nucleated RBCs**: Shonit™ successfully flagged the presence of nRBCs (nucleated RBCs) in several cases and nRBCs are calculated as an independent parameter. Additionally, the identification of the fragmented RBCs (schistocytes) by Shonit™ can enable the pathologist to give an impression of a haemolytic blood picture. The examples of a few cases along with the visual evidence of the cells identified by Shonit™ as nRBC are provided below:

- **Flagging Immature Granulocytes**: Shonit™ successfully flagged the presence of immature granulocytes (IG) in several cases, where the 5-part haematology analyser had failed to flag the same. The examples of such cases along with the visual evidence of the cells identified by Shonit™ as IG is provided below:

Observations and key highlights:
Advantages over 5 Part Haematology Analyser

Monocyte Differentials: Shonit™ has proven to be more effective than the 5-Part Haematology analyser in reporting differentials for Monocytes.

Leukopenia Cases: Shonit™ has proven to be more effective than the 5-Part haematology analyser in reporting leukocytes differentials for leukopenia cases.

Flagging Nucleated RBCs: Shonit™ has reported (with visual evidence) the presence of nucleated red blood cells successfully in cases of haemolysis.

Flagging Immature Granulocytes: Shonit™ successfully flagged the presence of immature granulocytes (with visual evidence) in several cases, where the 5-part haematology analyser had failed to flag the same.

Advantages over Manual Microscopy

1. **Scanning:** As Shonit™ captures 120 images from the monolayer portion of a smear, it reports a more sensitive perspective about the peripheral blood smear.
2. **Identification of Rare Cells:** Shonit™ identifies the rarer cells such as monocytes, eosinophils, and basophils with greater accuracy in comparison to manual microscopy.

Discussion

Shonit™ has proven to be effective in locating and examining WBCs. Shonit™'s performance in providing differential counts demonstrates several advantages over 5-Part and 3-Part haematology analyser. WBC morphological analysis performed by Shonit™ is within acceptable inter cell counter variability limits. Shonit™ has demonstrated high sensitivity in identification of rarer cells such as monocytes and basophils. The 5-Part differentials provided by Shonit™ for WBCs lie well within the differentials reported by the Horiba 3-Part haematology analyser and Sysmex 5-Part haematology analyser. The mean-absolute-difference between 5-Part differentials reported by Shonit™ and the Sysmex 5-Part haematology analyser for Neutrophil, Lymphocyte, Eosinophil, and Monocyte Basophil and were 8.73%, 5.55%, 3.63%, 2.12%, 0.45%respectively. The time taken for the pathologist to review and authenticate a report was within 2 minutes.

Through this study, we can conclude that Shonit™'s performance in providing 5-part differential counts demonstrates advantages over a 5-Part Haematology analyser. WBC morphological analysis performed by Shonit™ is within acceptable cell counter variability limits. Sensitivity of Leukocyte differential counts reported by SHONITis high.

Shonit™ provides quality reports which are accurate and efficient. It saves time, accelerates the turnaround-time and increases productivity of pathologists. It has helped to overcome the time-consuming effort

associated with traditional microscopy. It can aid screening, diagnosis and analyse large batches of data. It can leverage multiplexing and drive down stream processes as well.

As pathologists, our professional value comes from our ability to give the most appropriate opinion based on visual images which amalgamates with the clinical background. Shonit™ gives this opportunity and the means to overcome bias of the human mind. It can serve as a powerful tool as an aid in hematopathology [1-15].

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