

Smartphone-generated images to estimate canine packed cell volume with enhancement techniques

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Abstract

Clinical diagnosis that necessitates the use of centralised facilities and site visits might be difficult for patients in resource-constrained or remote settings. As a result, the development of a low-cost test that uses smartphone data collecting and transmission to enable illness self-management and point-of-care (POC) diagnostics would be advantageous. The PCV of canine blood collections can be extrapolated using a smartphone photograph. Filter paper has been utilized to hold the plasma samples, and photos were taken in various conditions using a smartphone. These findings were then contrasted with PCV values performed on the identical samples in accordance with WHO recommendations. Many samples were examined, and it was discovered that smartphone photos taken in a controlled setting could accurately predict the samples' PCV. Whether testing samples of a regular erythroid mass or a polycythemic sample, this projection was the most correct.

The findings of this study reveal that using Image Enhancement Techniques, smartphone-obtained photos can be used to estimate canine PCV. If this can be included into a smart device, it might be used in low-resource environments.

Keywords: Anemia, Diagnostics, Hematocrit estimation, PVC, Smartphone Camera, Canine blood samples

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1. Introduction

PCV measurements is a common diagnostics test in both initial care and referral contexts, and it is frequently associated as part of a minimal database once assessing patients at first appearance. [7] This allows for a quick assessment of the patient's spreading erythroid mass, enabling for important clinical choices must be made quickly amount of time. [4] Packed cell volume measurements have a number of advantages, including the fact that the results are accessible in 5–10 minutes. It just takes a minimal amount of blood, which can be obtained from EDTA or lithium heparin-treated plasma [15]. Plasma is indeed conceivable taken straight from an IV cannula in micro hematocrit tubes primed with anticoagulant in an urgent scenario or in tiny patients, with infants being typical example. The tiny volume allows for repeat sample, allowing for the tracking of trends and comparisons. Another advantage is that, after the initial investment in technology each test is cheap to run, making it a cost-effective test that can return a lot of data with a small amount of inputs.

The measurement of packed cell volume has some drawbacks. Operator-dependent variability is one of the most noteworthy. While taking into consideration differing operators expertise in veterinary medicine, two prior investigations found that the standard deviation of fluctuation is 0.09 L/L [9.0%] [2, 3]. According to the second research, this difference might be reduced by implementing a regular process to adopt because this method is not widely used at the moment, this difference is quite likely still evident in some of samples being evaluated. This discrepancy could lead to ineffective interventions or, on the other hand, a failure to act when needed.

Another flaw with this experiment is that it isn't adaptable because of equipment required. This restricts its use in some situations, like ambulatory horse or farm animal treatment in veterinary industry, or low-resource situations in the human's field. Hematocrit readers have certain advantages, albeit the expense and auxiliary equipment required may limit their use.

The risk of biological materials is a more pressing problem in human medicine; however, it is nevertheless significant in veterinary medicine. Sharp-related accidents from manipulating glass micro hematocrit tubes, as well as blood aerosolization from sealing failure during centrifugation, provide a possible risk to users.

In the medical industry, smartphone use is becoming more common, and it has been utilised to supplement or improve conventional diagnostic approaches. There have been earlier reports of forensic medicine using smartphone-obtained photographs to age plasma spatter. [16] There have also been reports of usage of auxiliary equipment that allows for the calculation of haemoglobin concentration. [5, 12]

The goal of this work was to see if photos taken with a smartphone could be enhanced to decrease noise, and that PCV could be extrapolated using generally available technology. A secondary goal was to see if a standardised blood volume and a supervised environment were required to increase accuracy of results. The premise was that photographs taken in controlled environment with a standardised amount of blood stain would have the best correlation with annual PCV.

2. PCV TEST

Although the fact that packed cell volume, also known as hematocrit, is tested dozens of times every day at the Canine Medical Center, most pet owners have never heard of it. If one of your pets has had a bad case of anaemia, you may have heard about this test from your veterinarian. Packed cell volumes, or PCV, is a measurement of the number of red blood cells in the blood. Other ways for determining the amount of red blood cells exist, but they require more time and complex laboratory equipment. The amount of red plasma cells in a drop of blood may be counted in the laboratories; there are million in a drop of plasma Haemoglobin, the oxygen-carrying protein found

inside red plasma cells can also be examined; haemoglobin, like red plasma cells decreases when a patient is anaemic.

Blood is a mixture of serum and cells in general. The PCV test determines how much blood is made up of cells. If the PCV gives you a 50 percent result, it signifies that 50 ml of cells are present in every 100 ml of blood. When the RBC number rises, the PCV total reading rises with it. Dehydration can also cause this figure to rise.

Performing PCV and total solids testing is a fairly normal and straightforward test that many hospitals perform. The test may be performed by anyone in the medical field, but interpreting the results is the difficult part. The observations can reveal a wealth of data on patient's condition as well as aid in the planning of the next therapeutic step.

The proportion of red plasma cells in floating blood is known as PCV [17, 18, 19]. A lower PCV indicates diminution of red blood cells due to a variety of factors such as cell death, blood loss, and bone marrow failure. Dehydration or an unexpected enhance in red blood cell synthesis are the most common causes of an elevated PCV. The term "TS" refers to a measurement of blood antigens Albumin, globulins, and fibrinogens are examples of these proteins. Reduced TS indicates that the animal is losing protein due to a multitude of factors such as blood loss, PLE, PLN, or starvation. Increased TS is commonly associated with dehydration; however, it can also be found in certain chronic conditions.

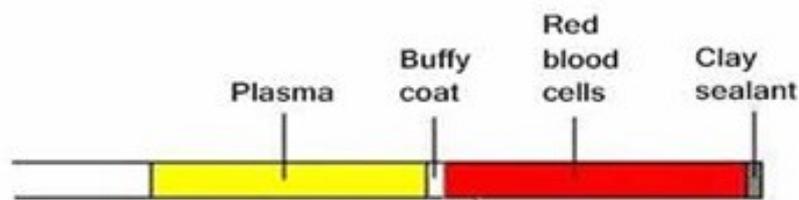


Figure 1: Packed cell volume

Observing the buffy coat of a haemoglobin tube straight out of the centrifuge might also give you an estimate of white blood cell composition. The buffy coat is a 1 percent or fewer layers that rests above red cell layers and blood (and shouldn't be treated as part of PCV). A thick buffy coat can indicate a significant enhance in WBC count. Hemolysis, lipemia, and icterus must all be checked in the plasma layer. Along with the PCV/TS data, these features should be recorded. Remember to combine both numbers to receive your patient's whole clinical picture, and to monitor them during their hospital admission.

- **PCV, TS:** Dehydration is most likely the cause of this patient's condition. Both the PCV and the TS will increase when the water content of the blood decreases. As the sufferer rehydrates with fluid therapy, both of these levels should drop.
- **PCV, normal TS:** This patients may also be malnourished, but note that adding fluids will lower both readings, implying that protein loss is occurring. As fluids are delivered, keep an eye on the patient for evidence of hypoproteinemia and related clinical indicators (peripheral, hypotension edoema). This patient could have polycythemia, an uncommon disorder in which the body generates too many red blood cells.

- **PCV, TS :** This patient may be dehydrated and have a significant protein loss. This is more likely to occur after a recent trauma. Although splenic contractions have temporarily boosted PCV, low TS indicates that the patient is suffering from acute blood loss. It is critical to retest PCV and TS after commencing treatment in a trauma victim who is expected to lose blood.
- **Normal PCV, TS:** This is a common CKD cat situation. Anaemia and dehydration are most likely to blame for this patient's condition. The normal PCV may lead you to believe that this animal is well, but remember that as you rehydrate, these levels will decline, leaving you with anaemia to cure.
- **Normal PCV, normal TS:** Isn't normal good? Make sure the outcomes are appropriate for the patient. If this patient has recently been traumatised, there may be blood loss that isn't yet visible on blood tests. If the findings aren't what you expected, double-check the PCV/TS before starting treatment.
- **Normal PCV, TS:** This patient has a protein-losing condition (PLN, PLE), persistent diarrhoea, or certain liver and renal ailments. Be aware of the symptoms of hypoproteinemia (hypotension, peripheral edoema) and how to manage them.
- **PCV, TS:** The high TS most commonly indicates dehydration, and keeping in mind that adding fluids will lower the PCV even more, this patient is anaemic and requires careful monitoring of PCV and, most likely, addition of blood products.
- **PCV, normal TS:** This patient has RBC destruction due to a lack of production. We anticipate a drop in TS as a result of blood loss. Be on the watch for IMHA if only the red cells have diminished.
- **PCV, TS:** This patient is experiencing complete blood loss and must be constantly monitored. In order to treat this patients, blood products should be explored.
- **With this** knowledge, you may learn a lot about your patient just by looking at PCV/TS. You can anticipate their upcoming demands by applying critical thinking abilities and understanding the treatment plan for these sufferers.

A. Taking a look at the PCV

A reduced PCV indicates that the loss in RBC count is attributable to factors like blood loss, cell death, and decreased bone marrow synthesis. Enhanced PCV indicates that a patient is dehydrated and that there are more RBCs being produced. You may also obtain an estimate of the WBC concentration by glancing at the tube coming out of the centrifuge. Normally, this buffy coat is found between both the blood and red cell layers. (This should not be included in the PCV test.) Lipemia, hemolysis, and icterus should all be looked for in the plasma membrane.

B. Getting Ready for the PCV Test

There is no need to prepare for PCV test in advance. If you are concerned about test, talk to your doctor and express your concerns. In addition, you must tell the doctor about any medications you've been taking. Your must fast before the test if you have any underlying medical issues.

C. Utilization of Packed Cell Volume Test

A low PCV indicates that patient is anaemic and has a low quantity of red blood cells. To diagnose the underlying reasons of anaemia, doctor may require patient to undergo further testing. The appropriate treatment will be offered.

A. Evaluating the PCV Test

The PCV test is determined with use of automated analyzer, rather than being tested directly. Doctors calculate the final quantity by calculating the red cell count by the average cell size. PCV is significantly less precise than hematocrit because it includes small quantities of venous plasma that is stuck in between two red cells. An estimated hematocrit in percentages can be calculated by doubling the haemoglobin concentrations and subtracting the digits.

The PCV can also be measured using a cuvette and centrifuging heparinized blood in it for around 5 minutes at about 10000 RPM. This process assisted in the separation of the blood into separate layers, and the final quantity of the PCV is calculated by dividing the volume of the total packed RBC by the entire volume of the blood test. Because a tube is also employed, it can be used to calculate the distances between layers.

Optical technologies such as spectrophotometry can also be used to measure hematocrit levels. Distinctions can be used to build a linear relationship between the vision system of sample passing through glass tubes at relatively high melting frequencies and the product including the luminal diameter and haemoglobin.

B. When Does A Low PCV Reading Occur?

There are several factors that lead to the low PCV reading. These are some of them:

- Iron or vitamin (B12 or folate) deficiency, as well as mineral deficiency
- Bleeding
- Rheumatoid arthritis and other inflammatory disorders
- Kidney disease
- Haemolysis, which is a condition in which the immune system destroys RBCs too soon. This develops as a result of organ injury and inherited RBC abnormalities.
- Cirrhosis of the liver
- Medications, particularly treatment
- RBC anomalies or diseases involving haemoglobin, such as myelodysplastic syndrome, cancer, marrow illnesses, and malignancy
- Dehydration is one of the most common reasons of elevated PCV levels. The levels return to normal with proper hydration, but it can also cause polycythaemia, a disease in which there are more RBCs than usual.

3. Image enhancement

Honing, contrast modification, filtering, extrapolation and magnification, pseudo colouring, and other image enhancing techniques are available. The most difficult aspect of picture enhancement is measuring the enhancement criterion. As a result, many picture enhancing approaches are empirical, requiring participatory procedures to achieve satisfying results. Image enhancement, on the other hand, is still quite essential because it is useful in almost all image processing tasks Color picture enhancement may necessitate a colour image's colour balance or colour contrast being improved.

Color picture enhancement becomes more challenging not just due to the increased dimension of the data, but also due to the increased complexity of colour perception [8].

Image enhancement methods are employed to increase the image's look or to extract finer information from degraded photos. The main goal of image improvement is to texture so that the end result is more suitable for a given application than the final picture. A method that works well for one type of image may not be the greatest approach for enhancing another type of image. Color picture enhancement in the RGB colour space is shown to be ineffective since it ruins the original image's colour composition. As a result, HSV colour space is used by the majority of picture improvement techniques, particularly contrast enhancement approaches [9].

Methods for image improvement can be divided into two categories: transformation element approaches and spatial domain methods. The approaches in the first category work by changing an image's frequency transform, whereas the methods in the second group work directly on the pixels. Unfortunately, even with quick transformation algorithms, calculating a two-dimensional (2-D) transform for a huge array (picture) takes a long time and is not suited for real-time analysis.

Image enhancement is the practice of enhancing the readability or perception of information in images for human viewers while also giving better input for other robotic image processing processes. The main goal of image enhancement is to change the characteristics of an image to make it more suited for a specific activity and viewer. One or more picture characteristics are changed throughout this operation. A task's choice of qualities and how they are updated are unique to that task.

4. Materials and methods

Filter paper was utilized to hold plasma collections, and images were taken in various conditions using a smartphone. These findings were then contrasted to PCV values performed on identical samples in accordance with WHO recommendations.

- **Collection of Samples** Canine samples were taken from a number of patients that came into the Hospital for Small Creatures. These specimens were extra and would have been discarded as clinical waste if they hadn't been used. They were chosen exclusively on the basis of availability, and no samples were left out of the analysis. Entire samples were examined within 12.0 hours after collection and were kept cooled in the interim.

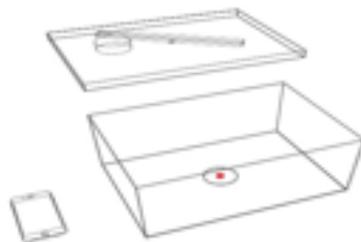
- **Equipment** A controlled environment was built to reduce outside sources of fluctuation, particularly illumination. A standard white paper-based box with dimensions of 27cm x 35cm x 20cm was utilized to accomplish this. A 0.5cm radius hole was drilled in lid of this box to accommodate the camera lens (Figure 2) while preventing external light from entering. The same paper-based substance was used to seal the handle spaces. To prevent any crimson pollution, single sheet of dazzling white 80.0 g/m² A4 paper was inserted at the base of the box and replaced continuously to overcome any colour analysis of succeeding Samples. On the underside of the lid, a conventional 35.0 centimetre, 30.0lumen, battery-powered lights strip was mounted. For each test, a new piece of 90.0mm rank 1.0 filter paper was utilised. To ensure uniform alignment, a rectangle size of filter material was replicated onto back of bucket.



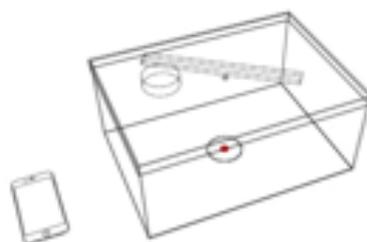
Step-1



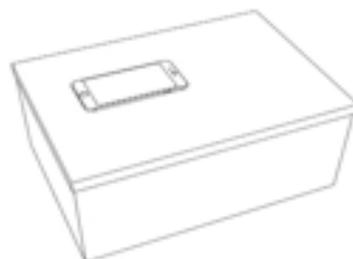
Step-2



Step-3



Step-4



Step-5

Figure 2: Schematic representation of the controlled environment created for analysis

The location of the smartphone on the exterior of the lid was marked to guarantee that it was always in the same spot. Figure 3 shows examples of photos acquired using this technique.

Figure 4 shows representative photos obtained, as well as from such a flat plane, a schematic illustration with this appearance. All of the photos were taken with a smartphone.

- **Image acquisition**

The two variables that needed to be standardised were the amount of blood and the setting in which the photos were taken. The distance between camera and blood patch, angle of lens in reference to filter paper, the amount of movement when the image was collected, and ambient illumination are all potentially confounding elements that are mitigated by the controlled environment.

On the centre of the filter paper, a drop of mixture blood was put. A pipette and tip were utilized to aliquot exactly 20.0litres of blood to standardise volume. For non-standardized volume, disposable 2mL plastic droppers were used to provide 1 drop, with a drop volume of 22 L according to the supplier. The sampling circumstances for each sample were analysed in the same order for each test, beginning with the pipette in an unsafe way and ending with dropper in a controlled environment. If the material was to be evaluated in a controlled setting, the filter paper has been either left in place or moved to box after 30 seconds. Five photographs were taken in rapid succession using smartphone, each taking around a second to capture, so order to offer a sample of images to compare for unexplained variance.

This was done to provide the plasma spot enough time to wick into paper while yet allowing approach to be conducted faster than traditional PCV measuring method. The shot was taken at height where filter paper filled screen in unmanaged situations. This was not a measured length, when photographs were taken in absence of sunlight and with only diffuse ceiling fluorescent strip bulbs, no changes to the room's illumination were made. The photos were thoroughly examined for any signs of movement artefact and would have been re-acquired if this had been discovered.

The filter paper with crimson spot was kept within box for a consistent environment. As a result, images were received from four different exploratory situations dropper utilized outside of a standardised environment pipette used outside of a standardised atmosphere dropper utilized inside a standardised atmosphere dispenser used inside a standardised atmosphere dropper used inside a standardised environment.

The coverslips were inserted at each end of one of microscopy slides for the alternative procedure, and the other microscope slide was then superimposed. The formed opening between the slides was then filled via capillary action using a dropper. A sufficient amount of blood was injected to fill space between two coverslips. This was then put into box, and photographs were taken.

- **Image Processing**

Images from the cellphone were downloaded to a computer and then loaded into Image for processing. Figure 3 for filter paper technique and Figure 4.3 for microscopy slide technique show examples of the images acquired.

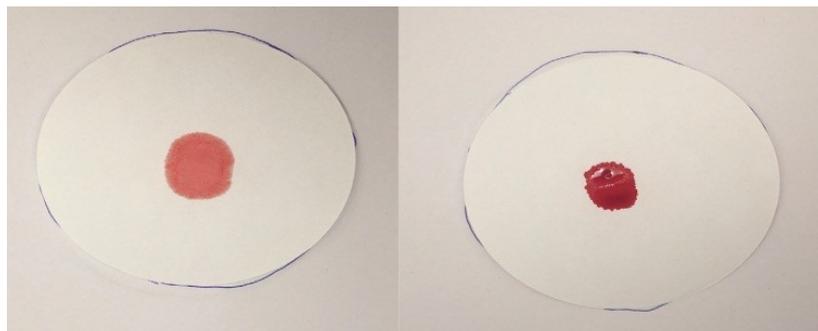


Figure 3: Representative photos from two cases using the dropper approach in a controlled setting, with a PCV of 0.05 L/L [5%] on the left and 0.45 L/L [45%] on the right.

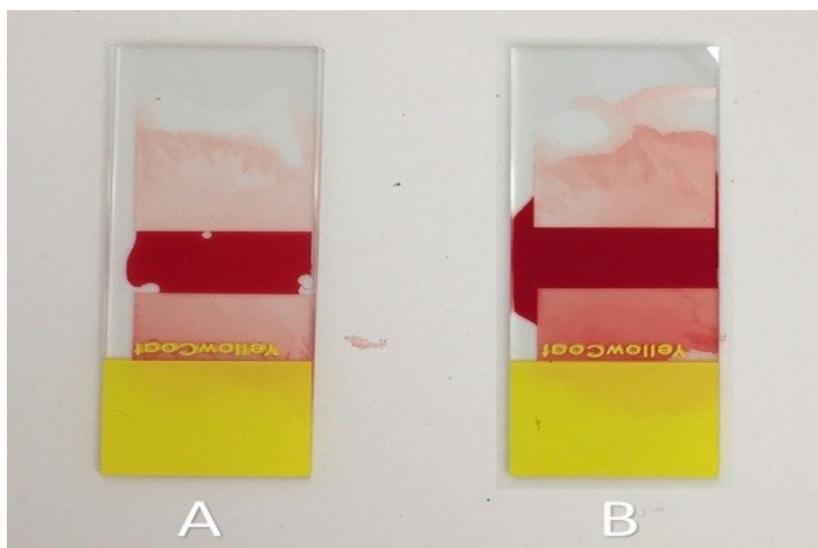


Figure 4: Image taken using the microscope slide technique.

The largest, visually homogeneous area within crimson spot was replicated with a stylus. This was done to escape including plasma that had not entirely infiltrated filter paper, which would have caused light reflections and changed the sample's mean colour intensity artificially.

The computer allocated a numerical value to each pixel in the enclosed area, with the value growing as the brightness of the pixel increased. The lighter and brighter the pixels are, the greater the mean colour intensity (MCI), which should be predicted to correspond to a lower PC. The images within the enclosed area are then assigned an MCI. This procedure was repeated for all of the photos acquired for each sample, after which a mean of the five photographs was determined. Between a single image and the average of the five photographs, there was no statistically relevant variation 20 samples were evaluated, and 1 of the 5 photos was picked at random and analysed to see if establishing a mean from 5 photographs was essential. After then, the single image was contrasted to the mean.

• Work statistics

In Microsoft Excel, the mean relative colour intensity was compared to the personally measured packed PCV. MATLAB was used to create the Bland–Altman graphs. The Kolmogorov–Smirnov test was used to determine whether the data were normal.

The relative colour fervor of blood spots was plotted versus measured PCV to create a scatter plot. The data points were then used to create a trend line with an associated R² value. To

see if the association was scientifically meaningful a Pearson correlation coefficient was used. This association was then classified as very weak (0.0–0.19), weak (0.20–0.39), moderate (0.40–0.59), strong (0.60–0.79), and very strong (0.80–1.0) according to Evans’ categorization.

A Bland–Altman plot was created to analyse the concordance between the expected and real PCV. The percent inaccuracy was computed by multiplying the disparity between expected and realistic PCV by 100. The mistake percentage’s standard deviations was determined as a whole. Based on observed PCV, the specimens were divided into three groups and classified using a single laboratory’s reference values: high (PCV >0.55L/L [>55 percent]), normal (0.38–0.55/L [38–55 percent]), and anaemic (0.38 L/L [38 percent]). For additional study, the anaemic group was further separated into marginal (0.20–0.37 L/L [20–37 percent]) and marked (0.20 L/L [20 percent]). For each, the mistake percentage’s standard deviation was computed. Because a defined cut-off hasn’t been selected in canine patients, a cut-off of 0.2 L/L (20%) was employed. This is a transfusion triggers used in humans healthcare [13] A 1-sample t-test was used to see if there was a meaningful difference amongst he mean of 5 samples and 1 sample chosen at random. A P-value of less than.05 was considered significant.

5. Result and discussions

I begin by taking image samples for a smartphone, then eliminate image noise and analyse the findings. In each of the four combinations, twenty-four samples were evaluated. Eight of the specimens were from anaemic individuals (PCV 0.39 L/L [39 percent]), one had erythrocytosis (PCV > 0.55 L/L [> 55 percent]), and the other 15 were inside the reference range (0.39–0.55 L/L [39–55 percent]). One sample was hemolyzed, while the other was lipemic. All of data was distributed properly (Kolmogorov–Smirnov, 0.21).

Figure 5 shows that when a plastic pipette was utilized in a controlled environment, there was a slight significant relationship with an R2 of 0.4049 (P.0001).

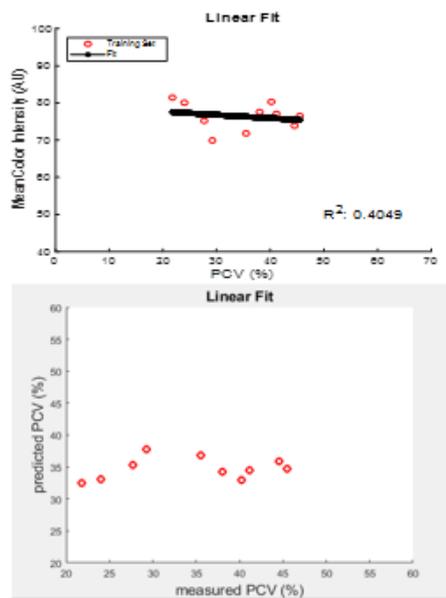


Figure 5: The picture analysis performed with a dropper in an uncontrolled setting (mean colour intensity) and observed PCV (n = 10) had a good correlation. The R2 of the best fit line is 0.4049 (P.0001). AU stands for arbitrary integer.

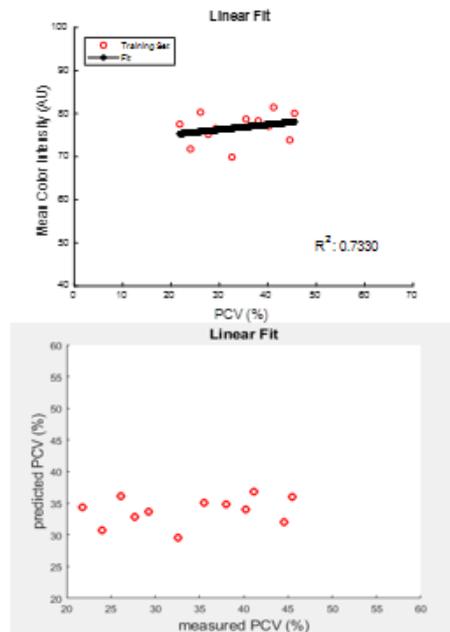


Figure 6: The image analysis (mean colour brightness) and the observed PCV (n = 12) had a linear connection when acquired using a standardised pipette in an uncontrolled environment. The R2 of the best suited line is 0.7330 (P.0001).

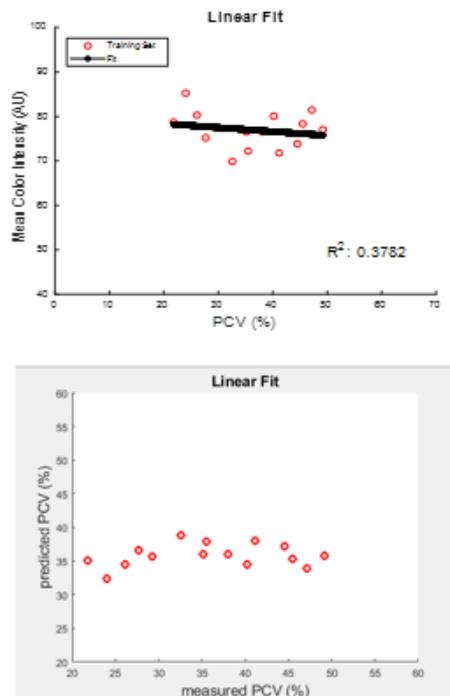


Figure 7: The linear correlation achieved amongst image analysis when received with controlled environment and a standardized pipette (MCI) and measured PCV (n = 15). Line of best fit has an R2 of 0.3782 ($P < .0001$)

There was a substantial association when a standardised drop from a pipette without ambient control was tested, as shown in Figure 6. There was a high association with a when a 20 L standardised drop from a pipette in a controlled atmosphere was tested, as shown in Figure 7. Figure 8

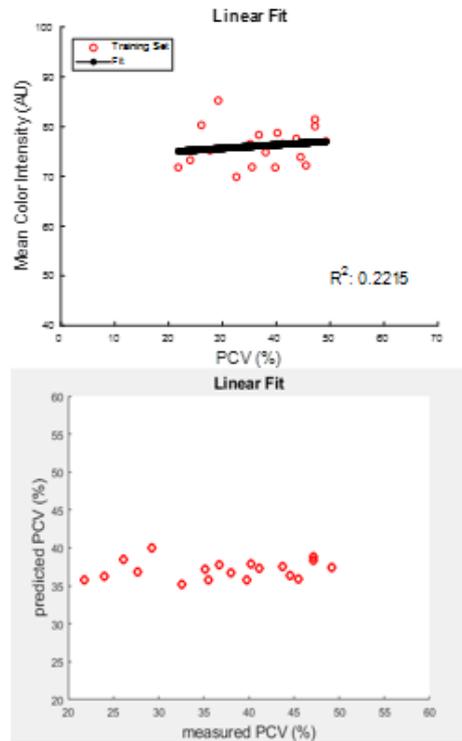


Figure 8: The linear connection between the picture analysis (mean colour intensity) and measured PCV ($n = 19$) acquired in a controlled setting with the use of a dropper. The R^2 of the best fit line is 0.2215 ($P > .0001$).

shows that when a plastic pipette with a contained way was employed, the connection was found to be high, with an R^2 of 0.2215 ($P.0001$).

In light of these findings, more samples were taken using the combination with the highest association, a glass pipette in a controlled atmosphere. A total of 45 data were added to the analysis, giving this approach a total of 69 samples. These additional examples were used to build the equations. Twenty-nine data were anaemic (PCV 0.38 L/L [38 percent]), 38 samples were in the standard range (PCV 0.38–55 L/L [38–55 percent]), and two samples were polycythemic (PCV 0.55 and 0.6 L/L [55–60 percent]). There were two hemolyzed samples and one lipemic sample in total. There were no samples that were grossly icteric. When only anaemic samples with a PCV of 0.38 L/L [38 percent] were included, the R^2 value was 0.85 ($n=29$). With a PCV of 0.2 L/L (20 percent), the R^2 value for the much more seriously anaemic samples was 0.78 ($n = 17$).

The connection between observed PCV and the projected PCV using dropper in controlled environment became stronger, yielding the equation of line $y = 0.5407 * x + 74.49$. Figure 9 illustrates this point. The anticipated PCV was computed by plugging the MCI into the line of best fit equation. The data in Table 1 was obtained using equations of line ($y = 0.542x + 74.945$) and additional nine medical specimens that had PCV determined based on drop technique in a contained atmosphere.

A 4-parameter logarithmic (4PL) model was created to account for the nonlinear connection between PCV and relative colour brightness. This method was used to examine the wider data set, which included the samples taken in the box with the use of the pipette. This 4PL produced curve had an R^2 of 0.926 ($P.0001$). The 95 percent degree of error (in percent) for mean of the projected PCV ranged from 7.8% to 7.6% when using the linear model. For all of the data combined, the variance of the percent mistake was 31.9 percent. The percentage mistake standard deviation was reviewed for groupings as follows: anaemia 48.4%, within normal limits 9.1%, and erythrocytosis 1.4

percent.

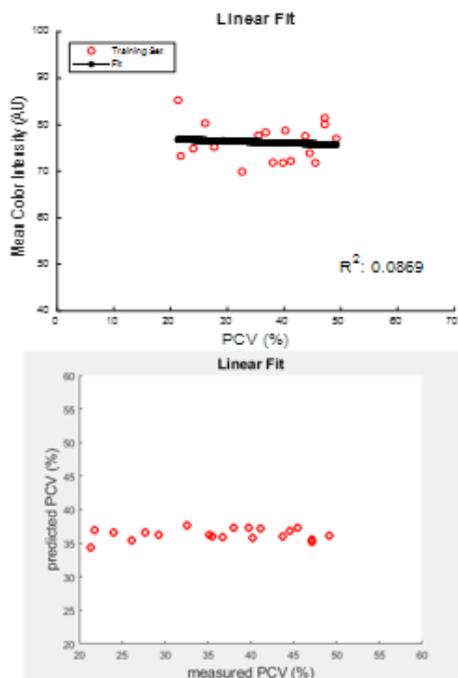


Figure 9: The linear connection between the picture analysis (mean colour intensity) and measured PCV (n = 20) acquired in a regulated setting with the use of a dropper. The R2 of the best suited line is 0.0869 (P.0001).

Table 1: The projected PCV was calculated using the equation of straight line, which was derived by plotting mean colour intensity (MCI) against measured PCV in a regulated setting using the dropper technique.

	measured_PCV	Predicted_PCV	PCV_difference
1	27.6840	36.5426	-8.8586
2	44.5173	36.8263	7.6910
3	26.0925	35.4554	-9.3629
4	32.5841	37.6703	-5.0862
5	49.2036	36.1479	13.0557
6	35.1331	36.2641	-1.1310
7	47.1771	35.2123	11.9648
8	47.1771	35.5057	11.9648
9	43.7145	36.0411	7.6734
10	39.7880	37.2654	2.5226

Description of code:

- First a folder having data i.e., blood images is selected.
- Selected blood images are used to calculate MCI (Mean Color Intensity).
- Then a folder having reports are selected.
- With the help of given information of RBC value and PCV value, measured PCV is calculated.

- Then for predicted PCV, Line of best fit is calculated by Least Square Method.
- PCV difference is then calculated by subtracting predicted PCV from measured PCV.
- Then Coefficient of Determination i.e., R^2 is calculated. It is used to tell that how much the algorithm is capable to model the data.
- Then graph is plotted between measured PCV vs MCI

As future work, the current work can be expanded to include the internet of things, cloud computing, and even e-government. Furthermore, Arduino technology has the potential to improve on the current work [11, 1, 6, 14, 10].

6. Conclusion

The current PCV measurement technique necessitates the purchase of multiple pieces of equipment, limiting its accessibility for both financial and logistical reasons, such as necessity for energy. Its portability is also limited due to the required equipment, restricting its applicability in field circumstances. These constraints could be solved with the use of a smartphone application. The technology's key weakness is that it requires a controlled atmosphere to enhance its correlation and prediction ability. The regulated atmosphere in this study was purposefully constructed from commonly available materials in order to enhance its application. The use of a uniform, widely available colour reference point to normalise the findings when analyzing the image is one technique by which environmental impacts could be mitigated.

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