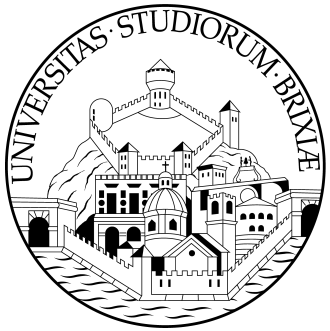
Hemolysis Identification Using Capsules Network



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DEPARTMENT OF INFORMATION ENGINEERING
Master of Science in
Communication Technologies and Multimedia

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Content

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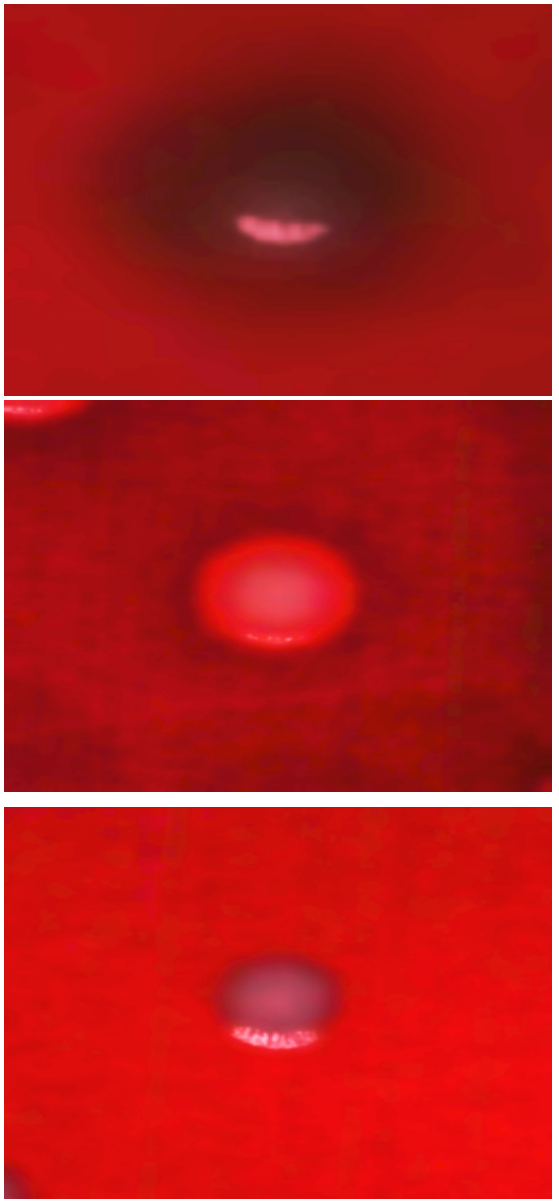
Introduction: bacteria culturing

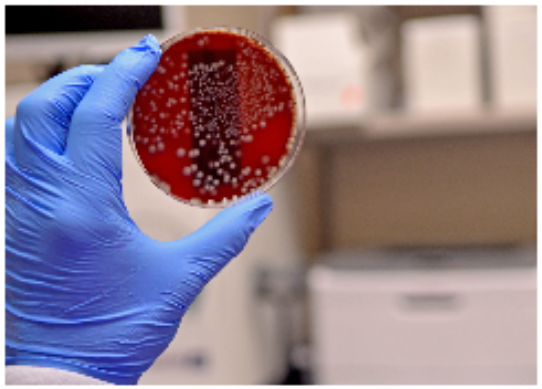
- Clinical Microbiology is concerned with the prevention, diagnosis and treatment of pathogenic diseases.
- A microbiological culture is a technique of growing microbial organisms that is useful for pathogens identification..
- **Blood agar**:Is a mixture of nutrient agar and 5% sheep blood:
  - Is used for isolation and cultivation of many types of pathogenic bacteria.

Introduction: hemolysis

- Some bacteria species produce exoenzymes that lyse red blood cells and degrade haemoglobin; these are called hemolytic.
- There are three different types of **hemolysis** on the agar plate: Alpha, Beta and Gamma.
  1. Alpha(α) hemolysis
     - Is a partial hemolysis.
     - Produces olive green discoloration.
  2. Beta(β) hemolysis
     - Is a complete breakdown of the red blood.
     - Produces a lightened(yellowish) and halo around the colony.
  3. Gamma(γ) hemolysis
     - No hemolysis.
     - Looks uniform and has shiny white growth.



Automated system for Clinical microbiology



DIGITIZATION

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Problem Statement

- It is challenging for the clinical microbiologist to quickly identify the hemolysis.
- It can be difficult for a microbiologist to clearly see hemolysis effects looking at digital images.
- The objective of this thesis is to design and evaluate an image analysis method for the detection and classification of hemolysis effects.

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Proposed Approach

- A deep learning solution, based on **convolutional capsule network** is used for classification of three types of images of hemolysis.
- The system should help the microbiologist to accurately classify hemolysis images.

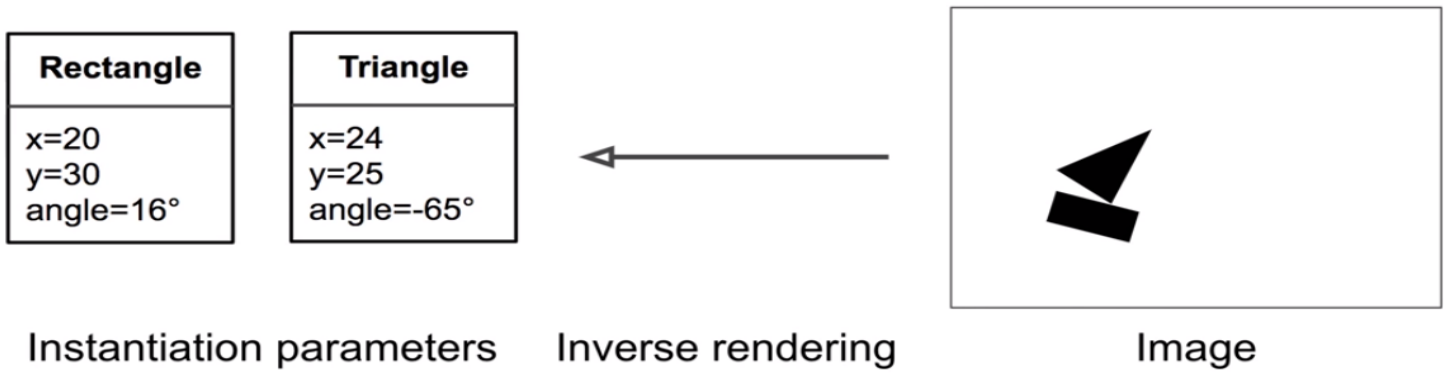
Proposed Method

- Capsule network(Caps Net) are an improvement on convolutional neural network(CNNs).
  - Solve problems of CNN which losses information regarding order and feature orientation.
  - Your brain can easily recognize this is the same object.
  - CNNs can not effectively handle rotations and other spatial transforms.

  - Capsule network is more robust to the change in transformation and how the image is positioned.

Proposed Method

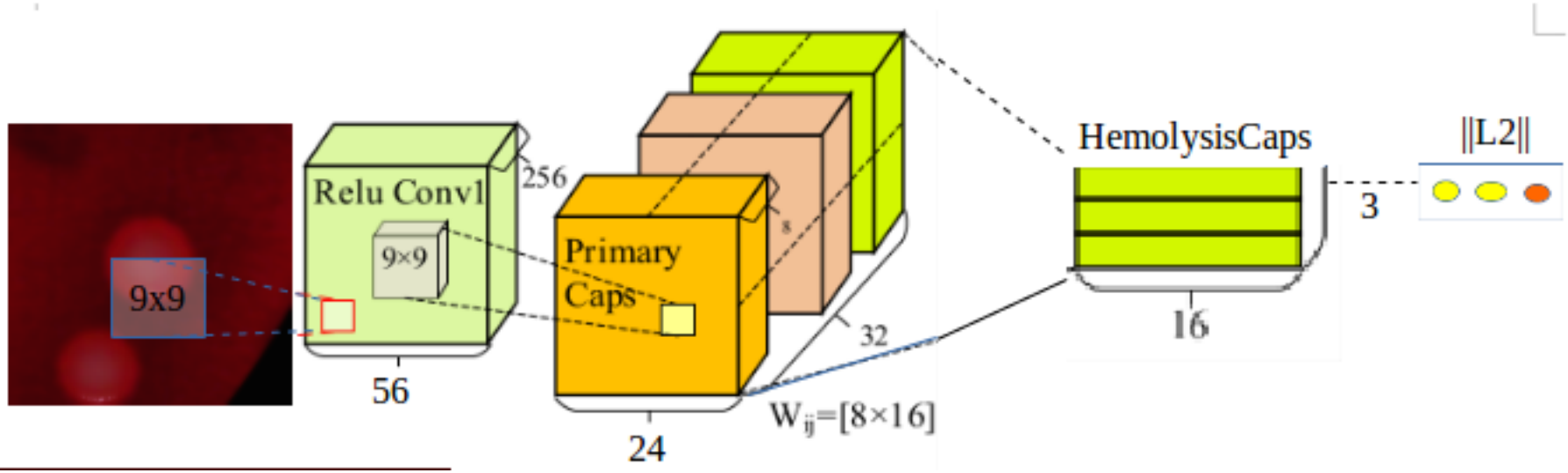
- Capsules are groups of neurons.
- Each capsule represent the presence and the instantiation parameter of multi-dimensional entity of the type that the capsule detects.
- If a capsule detects an object, the capsule outputs two things:
  1. The probability that an object of that type is present.
  2. Instantiation parameters including the precise pose.



- Capsule networks specifically implement an inverse rendering process.

Proposed Method: CapsNet architecture Encoder

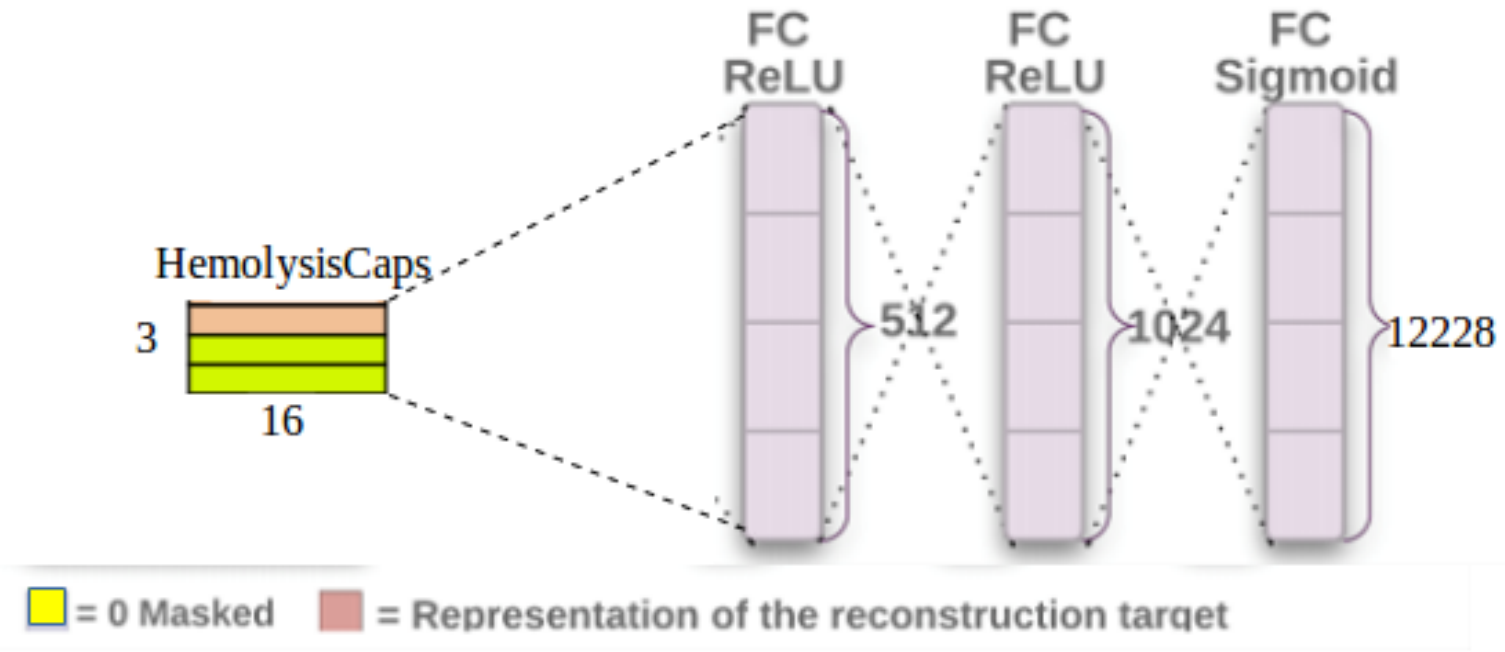
- A convolution layer is applied to extract primary feature maps.
- Primary caps layer.
  - This layer is used to divide feature maps into capsules.
- HemolysisCaps layer.
  - The 3 higher level capsule(of 16D) represent the 3 final "Hemolysis/class entities"
- Loss function
  - The max normal loss which allows to do classification



CapsNet Encoder

Proposed Method: CapsNet architecture Decoder

- Decoder structure to reconstruct an image from the HemolysisCap layer representation.
  - Reconstruction layer consists of only a few fully connected layers.
  - Minimize the loss generated between initial image and the original image.
  - This method acts like regularizer that easily cut back the over-fitting within the model.



CapsNet Decoder

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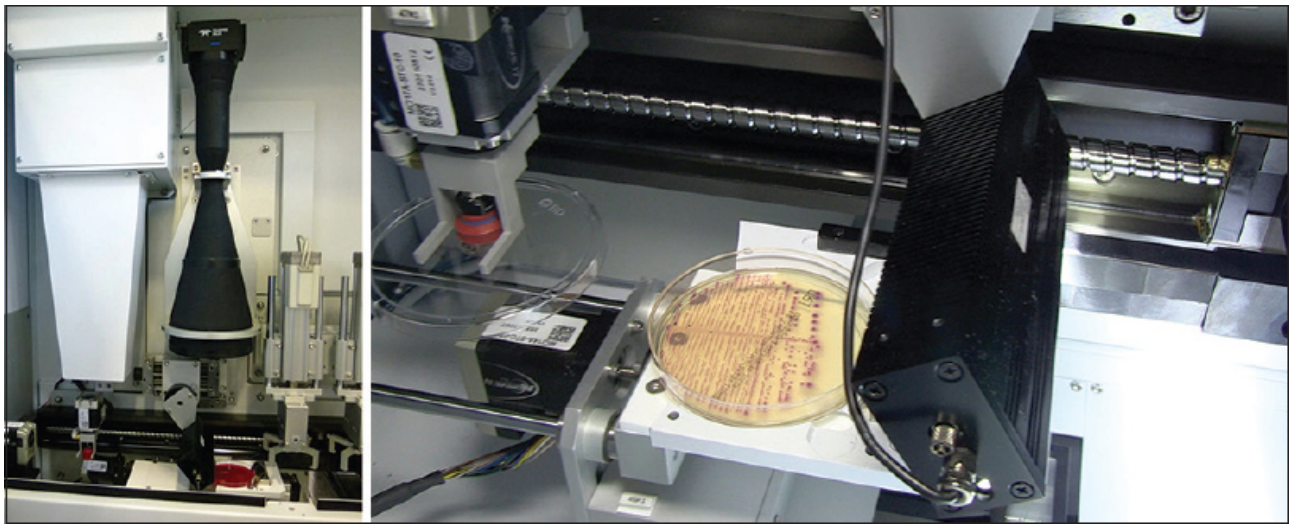
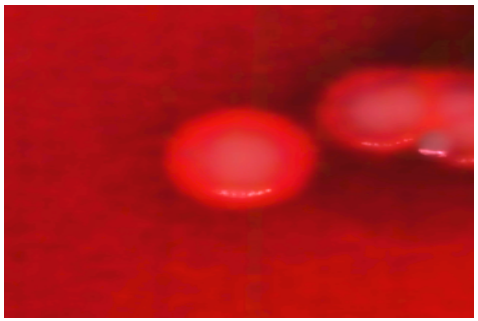
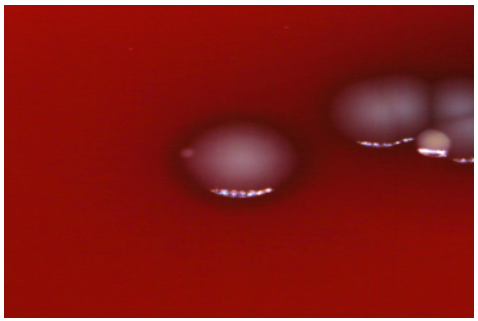
Dataset Description

- Hemolysis images are actually photos of back lit images and top lit images.





Back



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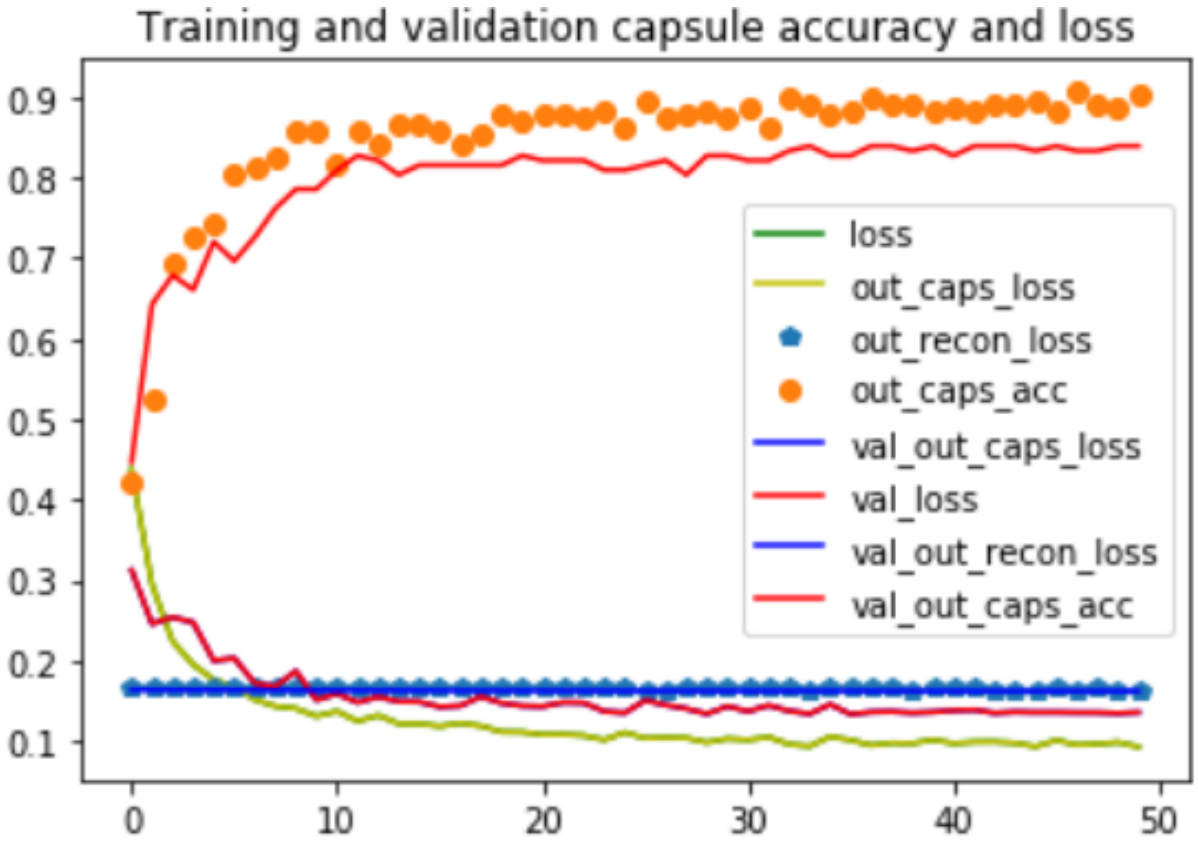
Dataset Description

- The dataset distributed as follow

Classes	Training data	validation data	Test data
ALPHA	200	56	56
BETA	200	56	56
GAMMA	200	56	56
Total	600	168	168

Training Accuracy

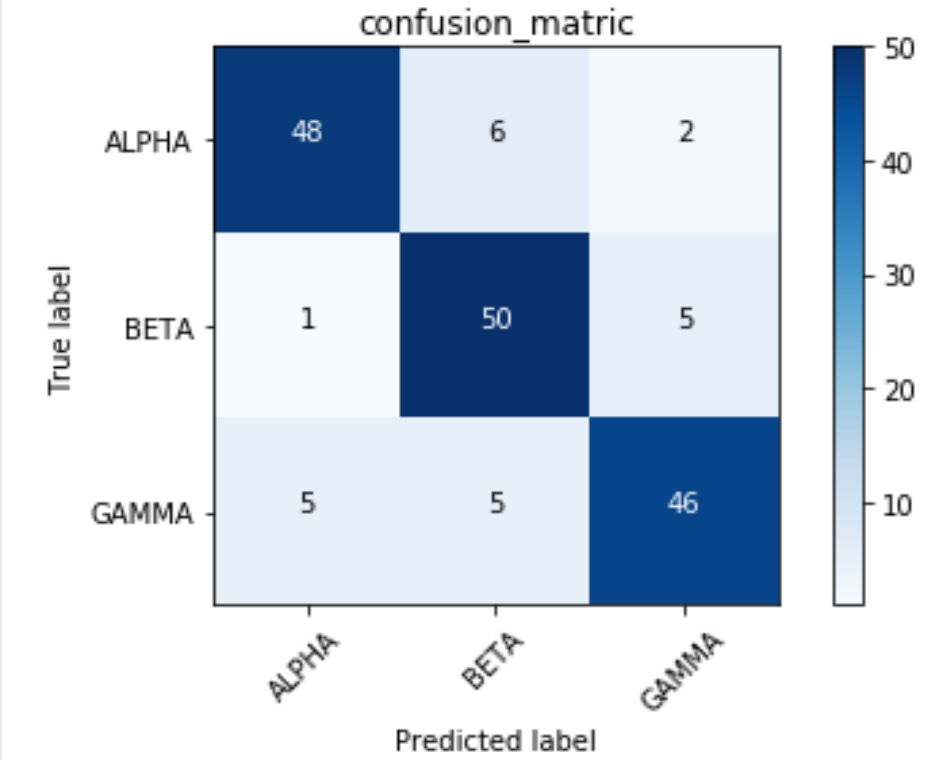
- It is clear that the accuracy is increasing and loss reducing per epoch.
- The training accuracy nearly 90%.



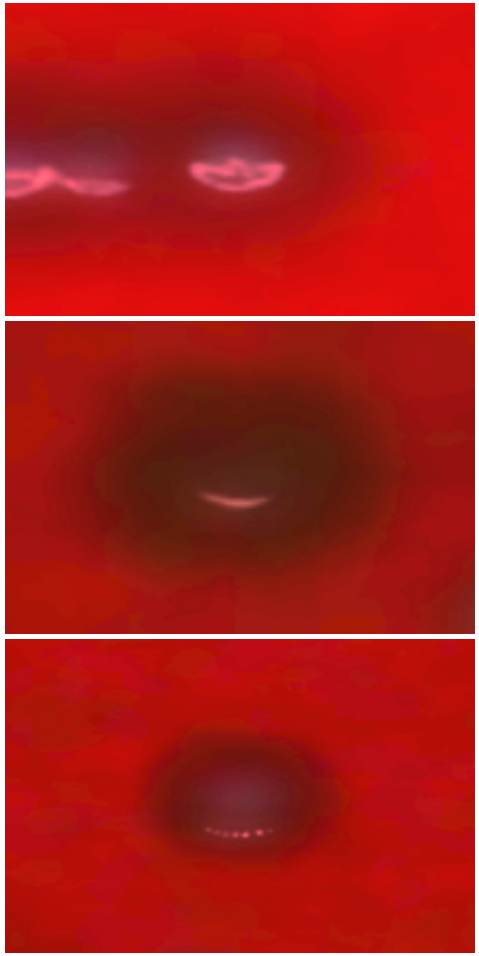
Prediction results

- β hemolysis is predicted better than the γ and α hemolysis.
- The percentage of β correctly predicted is 89.29%.
- α correctly predicted is 85.71%.
- γ correctly predicted is 82.14%.

Prediction results

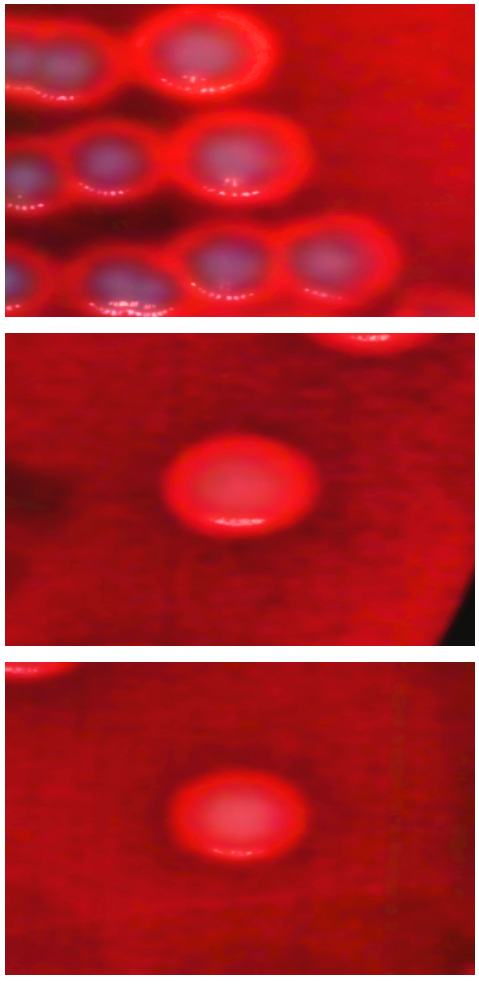


Result



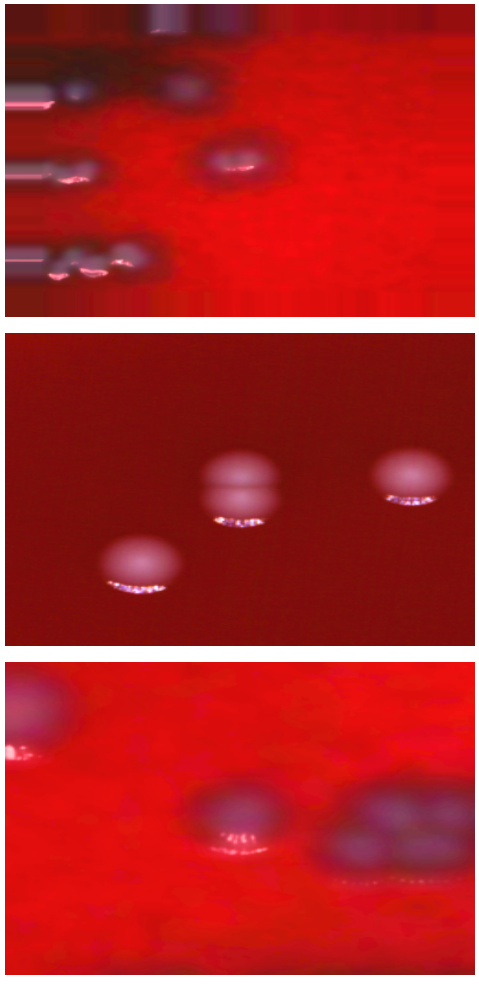
- Predicted α
  - Olive green discoloration is the key feature of α hemolysis.
  - makes them easily to identify as α in the prediction.

Result



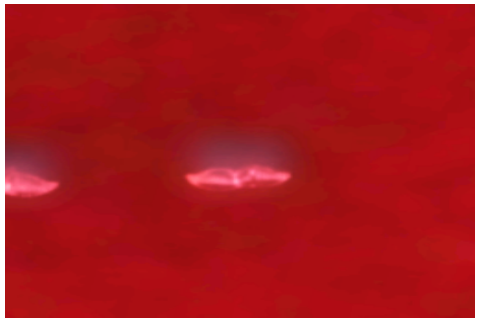
- Predicted β
  - If there is a yellowish halo around the colony and transparency
  - The capsule network can easily identified as β hemolysis.

Result

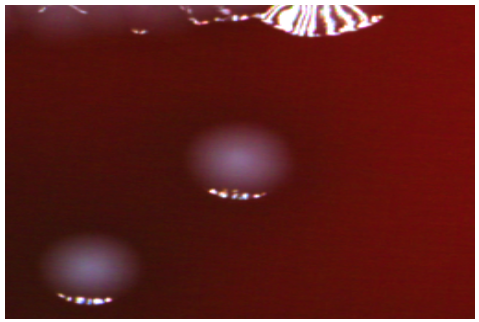


- Predicted γ
  - γ hemolysis has shiny white growth,looks uniform and red (the color of the blood agar substrate).
  - This features is used to identify them from the other correctly.

Result

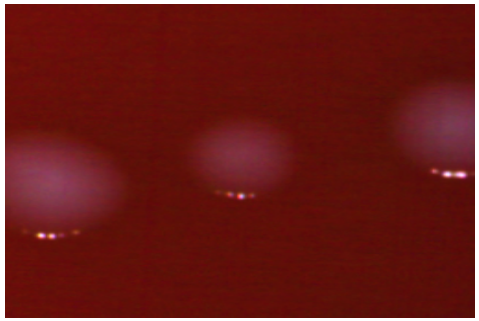


γ as α



α as β

as B.png as B.png



γ as β

- **Wrongly predicted**
  - β hemolysis wrongly classified as γ hemolysis due to some bright halo colored colonies.
  - α hemolysis wrongly classified as β hemolysis due to some bright shiny inside the colonies.
  - γ hemolysis wrongly classified as α hemolysis due some discoloration.
  - Back lit images are quite noisy.

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Conclusion

- Hemolysis identification using capsule network, which would help the microbiologists to classify the three different types of hemolysis faster.
- Can be used as an automated tool to assist doctors in disease control.
- Prediction accuracy of Hemolysis Identification Using Capsules Network with 85.7%.
- In the future work, more in depth analysis will be performed to optimize the architecture: number of convolutional layer, dimension of capsules in primary and Hemolysis capsule layers.


THANK
YOU