PROJECT REPORT

COMPUTER VISION FOR QUALITY CONTROL IN PCB MANUFACTURING

submitted by

Akanksha Bharambe	**C22018111148**
Niharika Dhande	**C22018111142**
Isha Joshi	**C22018111120**

in partial fulfillment for the award of the degree of

Bachelor of Technology in ELECTRONICS AND TELECOMMUNICATION ENGINEERING of SAVITRIBAI PHULE PUNE UNIVERSITY,

under the guidance of
Name of Internal Guide : - Prof.(Dr.) Prachi Mukherji

Sponsored by : - Atos India Pvt. Ltd.

MKSSS'S CUMMINS COLLEGE OF ENGINEERING FOR WOMEN, KARVENAGAR, PUNE – 411052.

Academic Year
2021 - 22

a) **Project title : - Computer vision for quality control in PCB manufacturing**

b) **Subject area : -** Machine Learning

c) **Nature of Project : -** Hardware and Software

CERTIFICATE

This is to certify that

Akanksha Bharambe C22018111148
Niharika Dhande C22018111142
Isha Joshi C22018111120

have successfully completed the work on their PROJECT TOPIC

Computer Vision for Quality Control in PCB Manufacturing

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in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY IN ELECTRONICS AND TELECOMMUNICATION ENGINEERING OF SAVITRIBAI PHULE PUNE UNIVERSITY,

in

M.K.S.S.S.'s CUMMINS COLLEGE OF ENGINEERING FOR WOMEN ,
KARVENAGAR ,
PUNE - 411052 .

Internal Guide	Head of Department	Principal
Dr.(Mrs.)Prachi Mukherji	Dr.(Mrs.)Prachi Mukherji	Dr.(Mrs.)M.B. Khambete

Sponsorship letter

Unify

Atos

To,
Dr. Prachi Mukherjee
HOD, Electronics and Telecommunication Dept.
Cummins College of Engineering for Women
Karvenagar, Pune - 411052

05-Oct-2021

Subject: Sponsorship letter for B.Tech Project.

Mode of Sponsorship: Only Technical Guidance

Dear Madam,

This letter is to confirm that our company, Atos India Pvt. Ltd. will be sponsoring technical guidance on a project that three students namely:

1. Akanksha Bharambe (C22018111148) - 4204
2. Niharika Dhande (C22018111142) - 4210
3. Isha Joshi (C22018111120) – 4218

from Final Year, B.Tech, Cummins College of Engineering for Women, Pune will be pursuing as Project Interns with Atos India Pvt. Ltd. under the guidance of Mr. Rahul Kulkarni, Director Presales (APAC & MEA).

Title of the project: Computer Vision for Quality Control in PCB Manufacturing.

Subject area of project: A.I. / Deep Learning / Machine Learning

Nature of the project: Hardware & Software

We hereby confirm our consent to demonstrate this project during exams, project competitions on/off-campus and publish it.

Sincerely yours,

Rahul Kulkarni
Director Presales – MEA & APAC
Atos Unify

Atos India Pvt Ltd
Unit No. 1401, Supremus, E Wing, iThink Techno Campus, Kanjurmarg (East) Mumbai - 400042
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Kulkarni.rahul@atos.net
Chamber of Commerce Atos India Pvt Ltd

Completion Certificate

Unify

Atos

To,
HOD, Electronics and Telecommunication Dept.
Cummins College of Engineering for Women
Karvenagar, Pune - 411052

29-May-2022

Subject: Project Completion Letter - Group 44 (B. Tech Project).

This is to certify that the project titled **Computer Vision for Quality Control in PCB Manufacturing** is successfully completed during the Academic Year 2021-22, by the following mentioned students of Cummins College of Engineering from E&TC branch.

1. Akanksha Bharambe (C22018111148)
2. Niharika Dhande (C22018111142)
3. Isha Joshi (C22018111120)

Objective of the said project is fulfilled in all respects to our satisfaction. Our best wishes to the team for future career.

Sincerely yours,

Rahul Kulkarni
Director Presales – MEA & APAC
Atos Unify

Atos India Pvt Ltd

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iThink Techno Campus,
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Chamber of Commerce
Atos India Pvt Ltd

Acknowledgement

We would like to express our heartfelt gratitude towards our industry guide **Mr. Rahul Kulkarni, Atos India Pvt. Ltd.** for his encouragement and highly valuable guidance throughout the duration of the B.Tech project work completion. We would also like to express our sincere gratitude to **Dharshini Prabhagar, Atos India Pvt. Ltd.** for helping us in solving errors in our project.
We would also like to thank our internal project guide **Dr. Prachi Mukherji (H.O.D. E&Tc)** for her constant and immensely valuable guidance, support, suggestions and her precious time in every possible way despite her hectic schedule throughout our project duration.
We take this opportunity to express our wholehearted thanks to all the E&TC staff members for their constant help whenever required. Finally, we express our sincere thanks to all those who helped and guided us directly or indirectly in numerous ways in completion of this B.Tech project work.

Abstract

In today's small scale manufacturing industries, the majority of the quality control work is done manually by checking one PCB at a time. And astonishingly out of around 200 manufacturers in India, almost 60% of industries are unorganized and small scaled. In such industries, using AOI (automated optical inspection) machines are unaffordable and have comparatively less product life.
We have proposed an affordable and accurate inspection system specially designed for detecting resistor errors during PCB manufacturing. This service does not require any high cost machines and it dramatically reduces any human error.

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List of Symbols , Abbreviations and Nomenclature

1) YoloV3 - You Only Live Once - Version 3.

2) PCB - Printed Circuit Board

3) CUDA - Compute Unified Device Architecture

4) AOI - Automated Optical Inspection System.

Chapter I

Introduction

Despite the existence of AOI (Automated Optical Inspection) systems, many small as well as mid-scale industries find it difficult to use them because of the high prices and comparatively lesser life of the machines. It is hence necessary to build an affordable automated system that inspects PCB and checks the values of components fitted on the board during quality control. Hence we endeavor to make a cost effective automation system, specifically to check resistor values on a PCB to make quality control easier in industry. For this, it requires a camera on top of a manufacturing line to monitor the PCB. This system will give the output whether to discard the given PCB or to pass it by checking resistor values. For now, it is only limited to the resistors but similarly, all the components from the PCB board can be verified.

Chapter II

Literature Survey

Sr. No.	Title of the Research Paper/ Website	Authors	Name of the Journal / Conference in which the Paper is published	Year of Publication	Hyperlink (or Weblink) to open the Soft-Copy of the Paper
1	PCB Fault Detection Using Image Processing	Jithendra P R Nayak	IOP Conference Series: Materials Science and Engineering	2017	Link
2	Automatic Segmentation and Classification of Resistors in Digital Images	Mia Muminovic,Emir Sokic	2019 XXVII International Conference on Information, Communication and Automation Technologies (ICAT)	2019	Link
3.	Quality control of PCB using Image processing	Rasika V Chavan, Swati A, Gautami D, Mayuri B	International Journal of Computer Application	2016	Link
4.	A PCB Electronic Components Detection Network Design Based on Effective Receptive Field Size and Anchor Size Matching	Jing Li, Weiye Li, Yingqian Chen, Jinan Gu	Computational Intelligence and Neuroscience - Hindawi	2021	Link

Chapter III

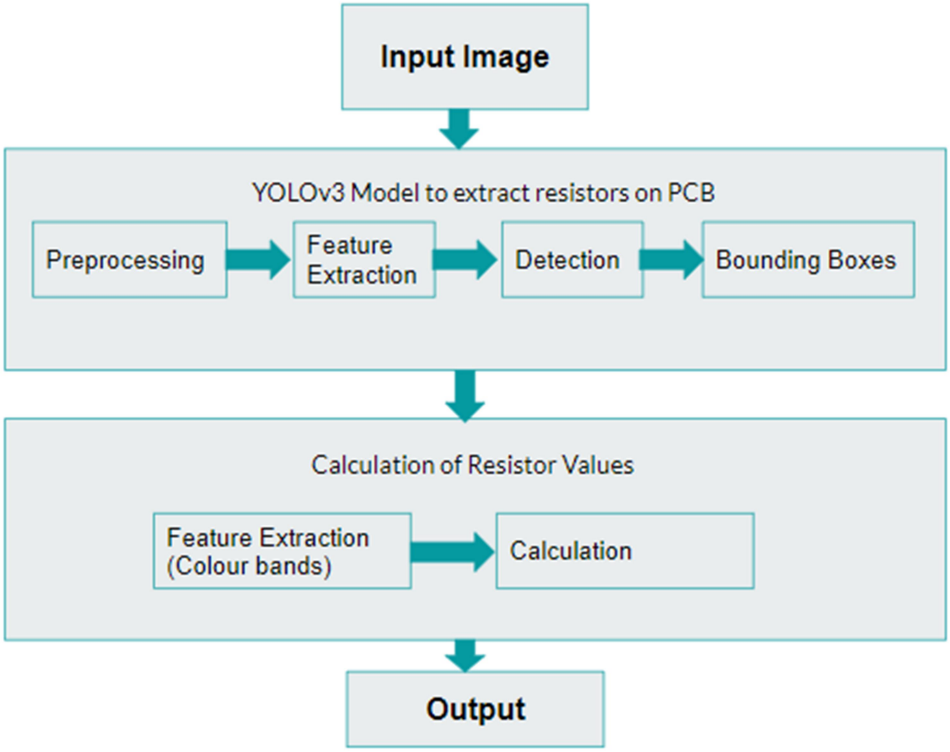
Specifications

1. YOLOv3 is used to detect the components, here only the resistors, and then to crop the resistor image from PCB.
2. To detect resistor color bands, resistors must be in a specific alignment, hence alignment of the crop image is done.
3. Once the resistor image is in required format, the value of the resistance is calculated using color bands.
4. If the calculated value is matching with the reference value (provided by manufacturer), then PCB will be passed, else it will be discarded.

Chapter IV

Methodology

Technical Block Diagram



Working of the system:

1. An appropriate dataset has been compiled which includes images of resistors, capacitors, as well as circuit boards to train the model. YoloV3 is not pre trained on resistors, circuits or allied components. Hence our model has been custom trained on the images that are appropriate for our model.
2. Input image of PCB is given to the program. YOLOv3 is used to detect the components, here only the resistors. To further analyze the resistor value, the detection box acquired from the detection algorithm will be made into a separate image. This new image is used to detect the resistor band value.
2. To detect resistor color bands, resistors must be in a specific alignment, i.e. in horizontal with golden/ silver band to the right side.
3. Once the resistor image is in required format, the value of the resistance is calculated using color bands by parsing each row and column for color reference.
4. If the calculated value is matching with the reference value (provided by the manufacturer), then PCB will be passed, otherwise it will be discarded.

Chapter V

Detail Design

1. YoloV3 algorithm for resistor detection-

*Upload dataset to drive and mount drive on colab
*Clone darknet repository on colab, make changes in cfg file, create data files and name files.
*Allow local CUDA to reduce time of execution
*Generate train.txt file.
*Train darknet on custom dataset and storing weights in backup folder on drive
*Testing the model for a test image and finding out the accuracy and class loss.

2. Algorithm for resistor value calculation-

*Read the image
*Find the color mean for width, height and channels.
*Calculating dark pixels in each column and similarly bright pixels for each column.
*Finding pixel intensity value for each row and classified it as bright or dark pixel
*Setting min and max to discard negative values below -1 to get desired band pixel values
*Calculating the mean of the matrix formed and hence deciding the colors for the same by pixel table.
*Resistor value is calculated.

Chapter VI

Results

Our system will not only reduce the human errors that occur in the quality control process of manufacturing PCBs for small and mid-scale companies, but also make the same task easier for the large scale companies.
As identifying a particular component and verifying whether it is the right one is a vital part of the quality control process, we have evaluated the accuracy of identifying the components(here, resistors) on the PCBs and then verified whether it is the same resistor or not.
In the conventional AOIs (Automated Optical Inspection systems), the machines only identify pre-defined components and check them. They are pre-programmed for the same and cannot be programmed remotely. Our system, however, can be programmed remotely.
Our performance metrics is accuracy which we have achieved to be 87.26% because it will tell the precision of our system to identify and verify the quality of components on the PCB.
Parameters under study are: 1) Proper identification of resistor
2) Identification of resistor color bands
3) Lighting conditions
4) Distance and other noise

Our industrial setup will consist of a camera that will click the image of a PCB on the assembly line and pass it onto the code. Here, the YOLOv3 component detection code will identify the necessary components(in our case, the resistor) and further the value of the component(resistor) will be calculated. The output will be displayed for verification.

The results are as follows:
1)Result of the component (resistor) detection:

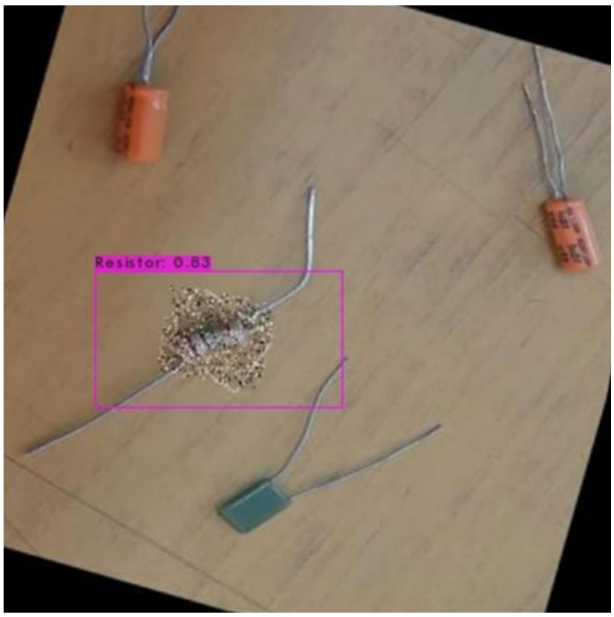


fig. 1 Component detection

fig. 2 Component detection

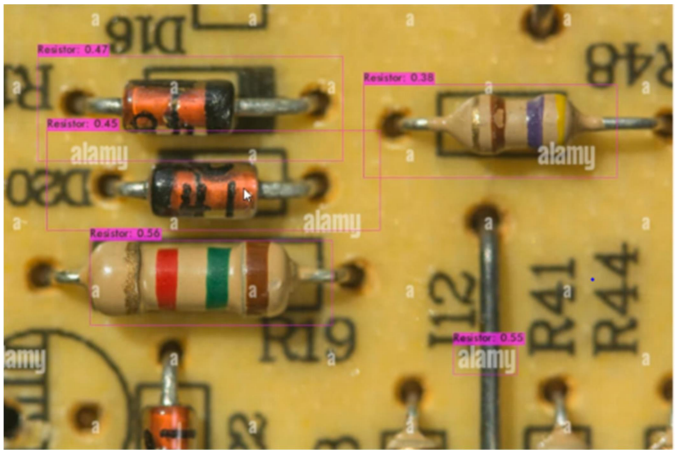


fig. 3 Component detection

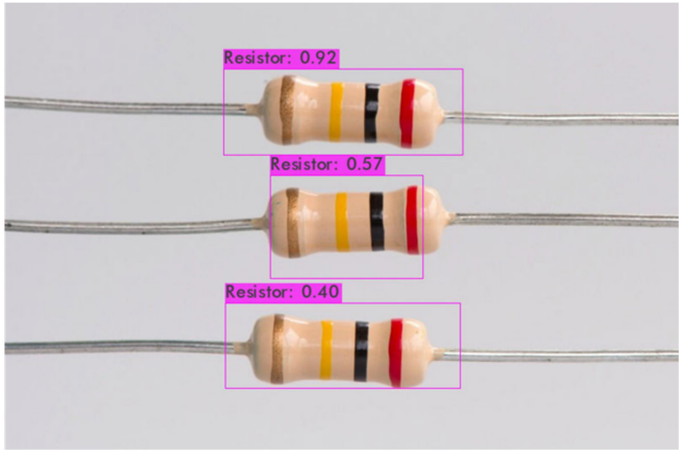


fig. 4 Component detection

2) Results of resistor band value calculation are:

Input:

Bands are: Red - Violet - Brown - Golden
Expected Output: 270 Ohms.

fig. 5 Resistor input

Observed Output:

```
sumc [1, 0, 70, 0, 0, 0, 0, 0, 0, 0]
code 2
sumc [1, 4, 0, 0, 0, 0, 0, 66, 0, 0]
code 7
sumc [1, 39, 0, 0, 0, 0, 0, 23, 0, 0]
code 1
result [2, 7, 1]
Resistance :  270.0 Ohm
```

fig. 6 Resistor value output

Precision/Accuracy Output:

```
 Allocate additional workspace_size = 12.46 MB
Loading weights from /content/drive/MyDrive/YOLOV3New/backup/yolov3_custom2_last.weights...
 seen 64, trained: 70 K-images (1 Kilo-batches_64)
Done! Loaded 107 layers from weights-file

 calculation mAP (mean average precision)...
 Detection layer: 82 - type = 28
 Detection layer: 94 - type = 28
 Detection layer: 106 - type = 28
356
 detections_count = 781, unique_truth_count = 418
class_id = 0, name = Resistor, ap = 87.26%       (TP = 357, FP = 55)

 for conf_thresh = 0.25, precision = 0.87, recall = 0.85, F1-score = 0.86
 for conf_thresh = 0.25, TP = 357, FP = 55, FN = 61, average IoU = 61.68 %

 IoU threshold = 50 %, used Area-Under-Curve for each unique Recall
 mean average precision (mAP@0.50) = 0.872586, or 87.26 %
Total Detection Time: 33 Seconds

Set -points flag:
 `-points 101` for MS COCO
 `-points 11` for PascalVOC 2007 (uncomment `difficult` in voc.data)
 `-points 0` (AUC) for ImageNet, PascalVOC 2010-2012, your custom dataset
```

fig. 7 Precision output

Conclusion

Component value detection and verification is much faster and accurate when the YoloV3 algorithm is combined with the detection code. YoloV3 is able to detect resistors with accuracy of 87.26%. After detection, to calculate the value of resistor only 4 band resistors can be provided as input for now with a light background where colour bands are distinctly visible. Dataset was created manually so there are less number of images available to train the model. Model accuracy can be increased by increasing the number of images. Training a custom dataset demands a significantly high GPU and we have completed 1100 iterations.

Our program currently does not work in real-time and hence some changes should be made before it can be integrated with the assembly line in order to start the quality control process. In our future scope, our models accuracy can be increased by adding a diversifying dataset and adding multiple classes of components to detect various circuit items including but not limited to capacitors , inductors, transistors and the placement of these components can also be verified. More iterations can be added to our current back detection files.Apart from component detection, other defects, namely missing holes, slivers, open circuit, mouse bites, short spurs, and spurious copper, etc. this model can be integrated with user interface on google cloud platform which will click images real time so it can be easily accessible for workers.

References

[1]M. Muminovic, E. Sokic, “Automatic Segmentation and Classification of Resistors in Digital Images,” in Conf. 2019 XXVII International Conference on Information, Communication and Automation Technologies (ICAT), Sarajevo, Bosnia and Herzegovina, 2019, DOI: 10.1109/ICAT47117.2019.8939034.

[2]R. Chavan, S. Chavan, G.Dokhe, M. Wagh, and A. Vaidya, “Quality control of PCB using Image processing”, International Journal of Computer Application, Volume 141 – No.5, pp. 28-32, May 2016.

[3]J. Li, W. Li, Y. Chen, J. Gu, “A PCB Electronic Components Detection Network Design. Based on Effective Receptive Field Size and Anchor Size Matching”, Computational. Intelligence and Neuroscience – Hindawi, Volume 2021, Feb 2021.

[4]Weibo Huang, Peng Wei, “A PCB dataset for Defects Detection and Classification”, 24 Jan 2019.

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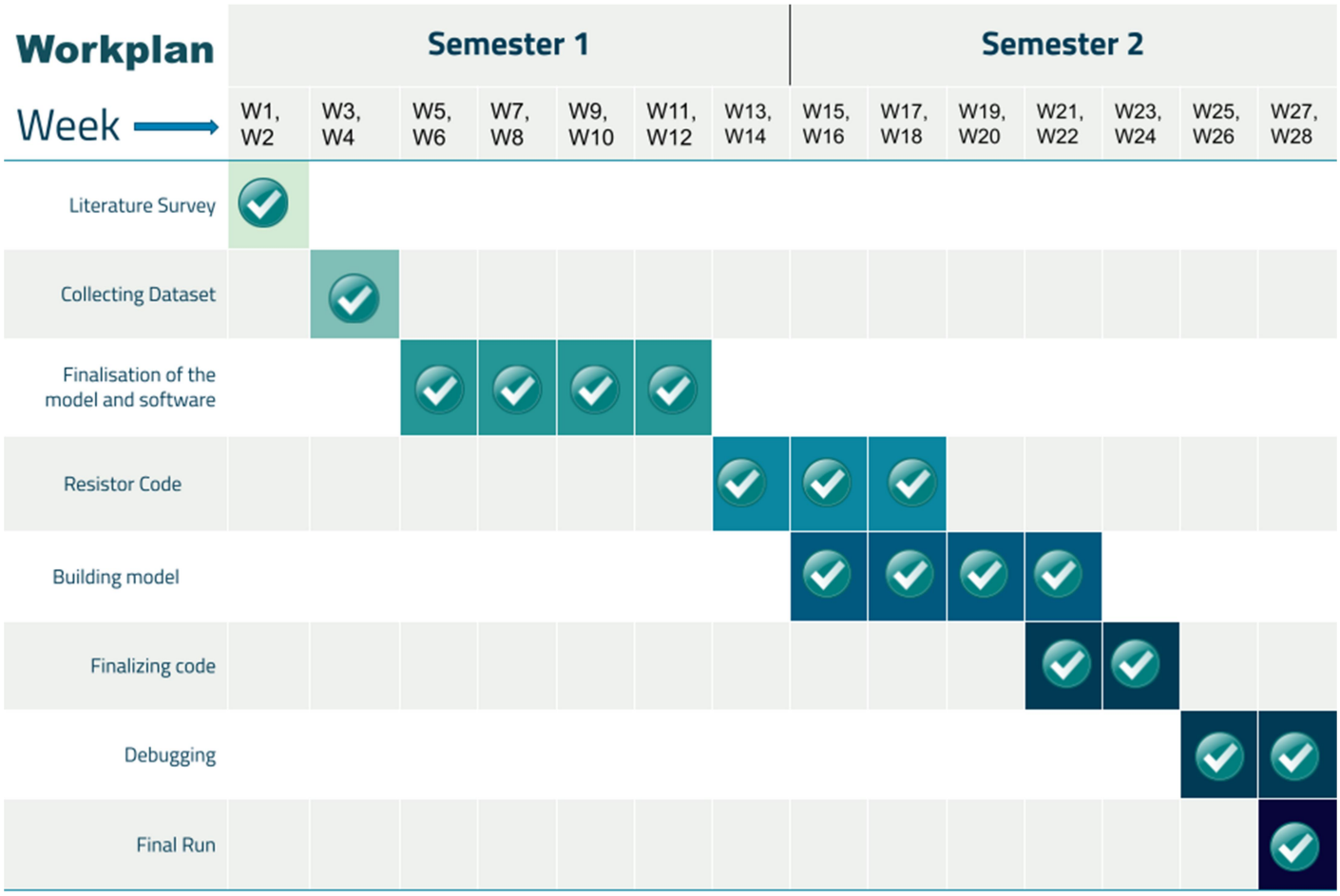
Appendices

Work Plan:



User Manual:

1)Save your PCB image in your google drive or anywhere on your local machine in jpeg or jpg format.
2)Upload the said image onto google colab.
3)Change the image URL in the last line and execute the program.
4)Your output will be the value of the resistor.

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