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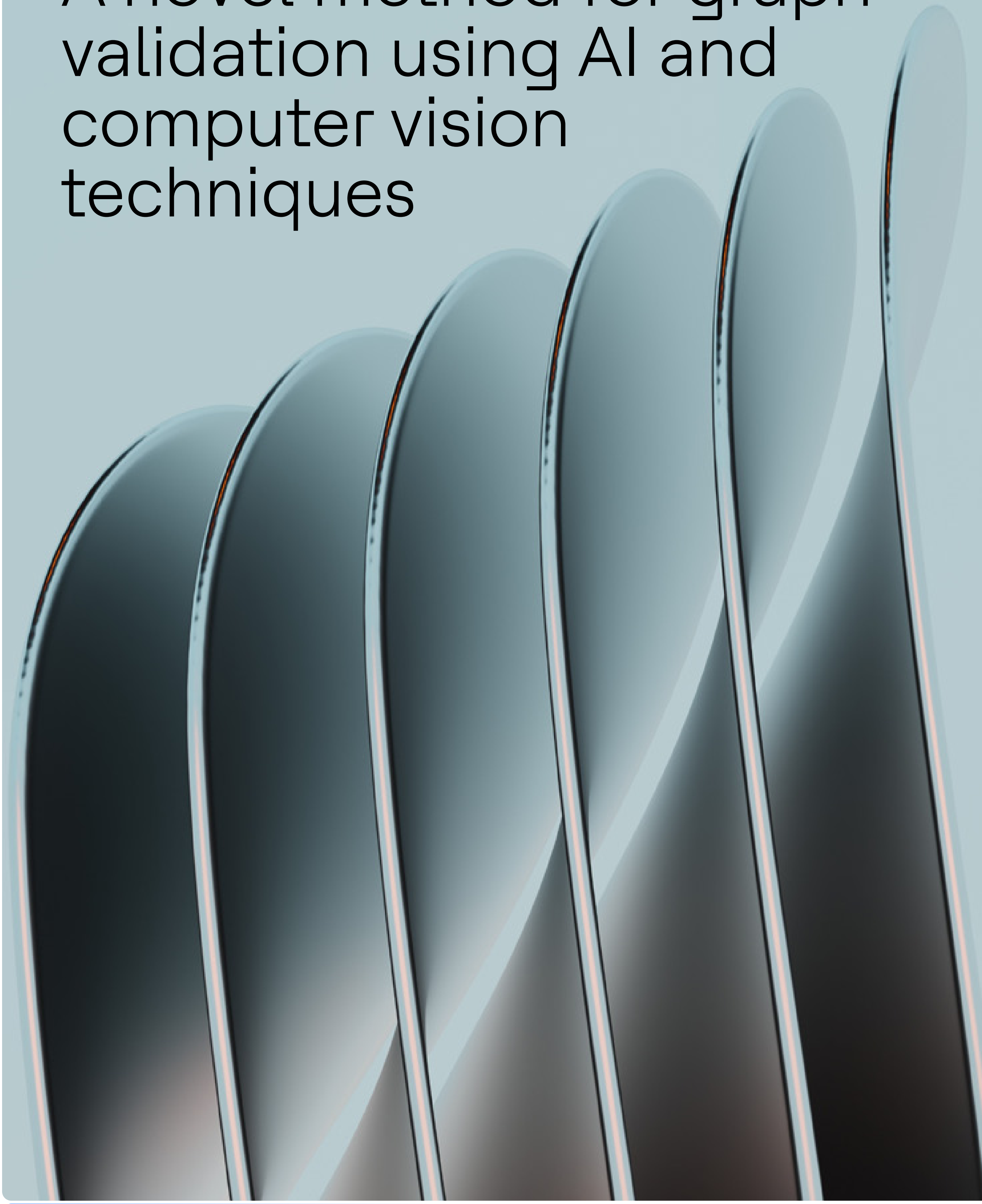
A novel method for graph validation using AI and computer vision techniques



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Abbreviations

Abbreviation	Descriptions
AI	Artificial Intelligence
OCR	Optical Character Recognition
CV	Computer Vision
DL	Deep Learning
JPG	Joint Photographic Experts Group
Bmp	Bit map
JIFF	JPEG Interchange File Format
PNG	Portable Network Graphics
WebP	Web Picture Format
CSV	Comma Separated Values

Introduction

A graph is a visual element that plays a pivotal role in representing a dataset by helping us understand the data in a way that no other representation can. These visual representations can be stacked/stream area graphs, line graphs, bar graphs, pie charts, histograms, scatter plots and many others.

In most industries, data is analyzed and represented in a graph based on metric requirements. Manual data validations can be a bit tricky and time-consuming as the graph representations increase in complexity based on layout and type. For instance, a simple vertical/horizontal bar graph followed by a stacked area becomes more complex when factors like background color and shading are included. In this whitepaper, we propose a technique to automate complex graph validations using AI. This automation process is achieved using image processing and deep learning algorithms.

Market trends

As the world becomes increasingly digitalized, technological advancements have inspired significant business transformations. Across industries, organizations recognize the need to innovate, reimagine and reinvent themselves to optimize their processes, tools, products and services. At the same time, consumer expectations are skyrocketing, forcing businesses to streamline time-to-market metrics, automate manual tasks, maximize resource utilization and scale productivity — all in pursuit of delivering exceptional user experiences. Simply put, the demand for automation testing — and in turn, automation testing — is at an all-time high.

According to MarketsandMarkets, the global AI market is projected to reach $310B by 2026, growing at a CAGR of 39.7% during the forecast period. The combination of AI and computer vision with automation technologies helps to eliminate human intervention in testing, in some cases automating the entire testing process. This will effectively eliminate the human element of testing, which is responsible for quality errors and high processing times. In other words, adopting technologies for the validation process will lead to higher quality and accuracy and faster times-to-market.

Problem statement

1. In the end-to-end testing process, there are challenges to automating graph validation for mobile and desktop applications
2. The automation must support external data content validation of graphs on Windows, Mac iOS, Android and Linux operating systems
3. The automation needs to support all types of visual representation, including stacked, stream, glucose profile, bar, line, pie chart and more.

Solution

Across industries, businesses grapple with huge volumes of data. that requires visual representation and validation. Graphs help distill the data into managable and meaningful chunks, making it easier to identify trends and insights. At the same time, it's crucial to have reliable data validation mechanisms for the data represented in each chart, as users need to examine the real-time and static data plotted along the graph's x and y coordinates. Our proposed solution is designed to overcome the challenges associated with the two main types of validation comparisons: image-to-image validation and external file validation.

Image-to-image validation

Image-to-image validations, which work for any type of graph, are useful in three different scenariosand may support any similar verification process based on the requirement.

1. Validate a real-time graph captured with a standard graph image with identical dimensions. Both graph images undergo selected pre-processing steps and are subsequently sent through computer vision algorithms for validation. All contents of graphs are validated to get a matching score, which is cross-checked with a threshold value to provide the results as Validation Pass or Validation Fail.
2. Validate a real-time graph captured with a standard graph image with different dimensions. While the images might appear similar, there will be a change in the position of contents (text/images) present in each graph. This type of validation is puzzling for a manual tester as it requires identifying the differences concerning alignment and positioning. In these cases, relying on computer vision algorithms alone might be challenging, and thus our solution utilizes deep learning with computer vision techniques. It virtually baselines the image dimension by leveraging customized geometric algorithms that facilitate in validating the contents regardless of the positional changes. All the

text contents will get extracted from images for validation using customized OCR with deep learning architecture. The plotted shapes (bar, pie, stack area, line, etc.) and their corresponding colors are identified using computer vision techniques for validation. We execute a validation process for the text contents and plotted colors in multi-dimensional images to provide results as Validation Pass or Validation Fail.

3. The third scenario is applicable when the nature of graphs is in the stack area, stream area or any similar format. Unlike bar/histograms, this kind of graph does not have a stable origin that changes according to the x- and y-axis parameters. In these graphs, each plot is in a continuous structure stacked or streamed over the other with different shades of color. The challenge occurs when the shades are of a similar primary color with minor variances in RGB values, making it difficult for the manual tester to differentiate the boundaries and color of the graph area for validation. This solution validates the baseline graph with a real-time graph image that encompasses computer vision, deep learning and inhouse arithmetic algorithms, where the results are again shared as Validation Pass or Validation Fail.

External file validation

Here our solution is to validate a graph image with an external file in any format (Excel, Access, Word, CSV, etc.) The external file may contain test cases or data related to the graphs that may comprise information like file name, intervals, values and the plotted color. It undergoes a filtration process to identify the information to be extracted and the mined data is organized into a standardized format which gets used for the verification process. The static/real-time graph image (bar, histogram, pie, etc.) can exist in any file format (png, jpg, Jpeg, Jiff, webp and more).

Validating external file data against graph data becomes increasingly complex when dealing with images that include color representations. During the testing cycle, the tester needs to read data values along with color information for each category in the external file and check its presence in the graph. This human process is time-consuming and prone to errors.

Our solution eliminates human intervention by automating the process using deep learning and computer vision algorithms. A deep learning algorithm is applied to extract textual information from the graph. Several challenges may occur while mining text information with certain font types and background color combinations but the text extraction algorithm implemented is proficient in processing and getting the text from graphs under these challenging circumstances. The validation is performed for various parameters in graph images, including text, numeric values, ranges, x and y coordinates, bar chart color, shape, etc.

Color validation of graph images involves verifying that the colors used in the graph are associated with the data displayed. This process ensures that the colors get validated even if there is a slight color variation that is not easily detectable with the naked eye. In general, each color has specific RGB values in which red, green and blue are the primary colors; the parameter of these colors changes accordingly. The external file contents will get validated with their corresponding values in the graph. The text and color values will get highlighted on the graph image with successful validations for user reference.

Case studies

A sample test case is described in Table 1 below. The test case document can be in any format. The test step contains data that needs to be validated on a graph where the type of graph depends on the test requirements. The data present in the test step needs to be aligned in a standard format for ease of processing. All the data contents from the test step need to be validated on the graph image.

Sl No	Step name	Test step	Expected results
1	To enter the population for cities described and verify the graph	Enter the values of Population for Cities: City::Buthur,Population::137:Blue City::Covai,Population::100:Blue City::Nyam,Population::73:Blue City::Palay,Population::200:Blue	Population for cities are validated in the plotted vertical bar graph
2	To enter the population and area for cities described and verify the graph	Enter the values for City,Area and Population: City::Buthur, Population::137:Blue & Area=35sq km: Orange City::Covai, Population::100:Blue & Area=20sq km: Orange City::Nyam, Population::73:Blue & Area=25sq km: Orange City::Palay,Population::200:Blue & Area=50 sq km: Orange	Population and area for cities are validated in the plotted horizontal bar graph

Table 1: Test case information

Case 1

Figure 1 shows a sample vertical bar graph plotted based on the values provided in Table 1, index 1 with its associated test step. The color representation, city name and population numbers are detailed in the test step. The data read from the test step is validated in the graph image contents using text extraction algorithms. The color name is validated using computer vision algorithms. The matched text contents and color names are boxed and highlighted in green. The overall result is updated as a validation pass when all the text and color contents are matched.

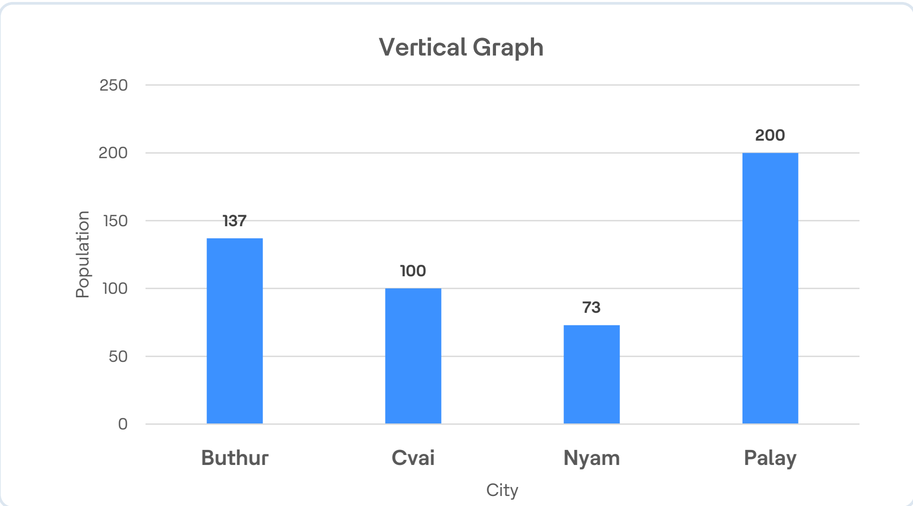
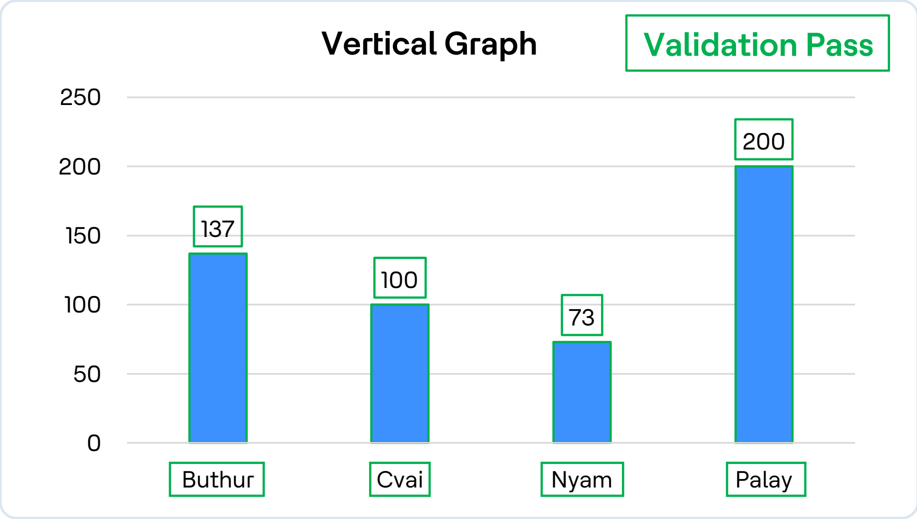


Figure 1: Graph actual output



Validated graph final result

Case 2

Figure 2 shows a sample stacked horizontal graph plotted based on the values provided in Table 1, index 2 with its associated test step. The color representation, city name, area and population numbers are detailed in the test step. The data read from the test step is validated in the graph image contents using text extraction algorithms. The color name is validated using computer vision algorithms. The matched text contents and color names are boxed and highlighted in green. The overall result is updated as a validation pass when all the text and color contents are matched.

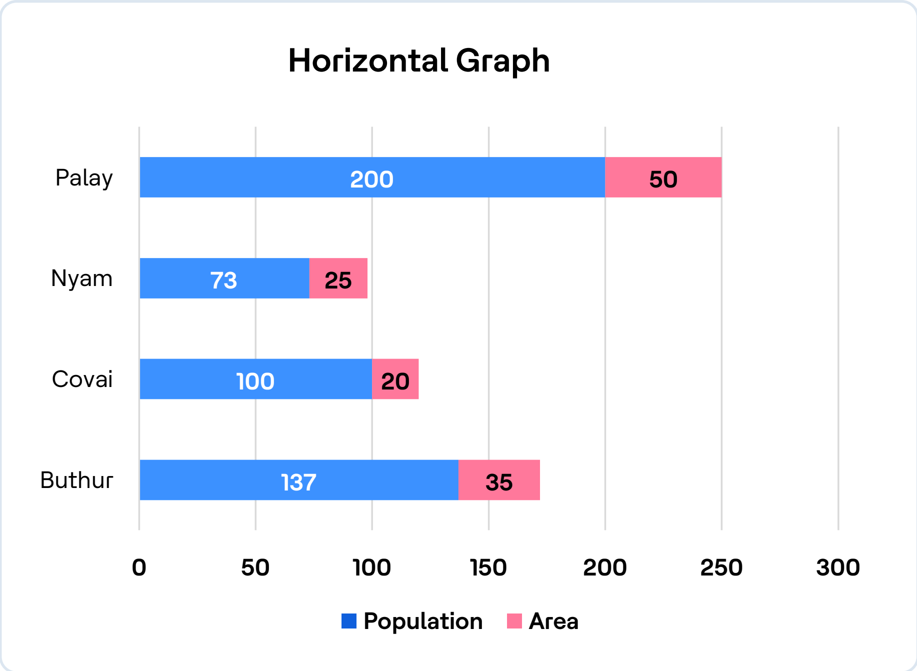
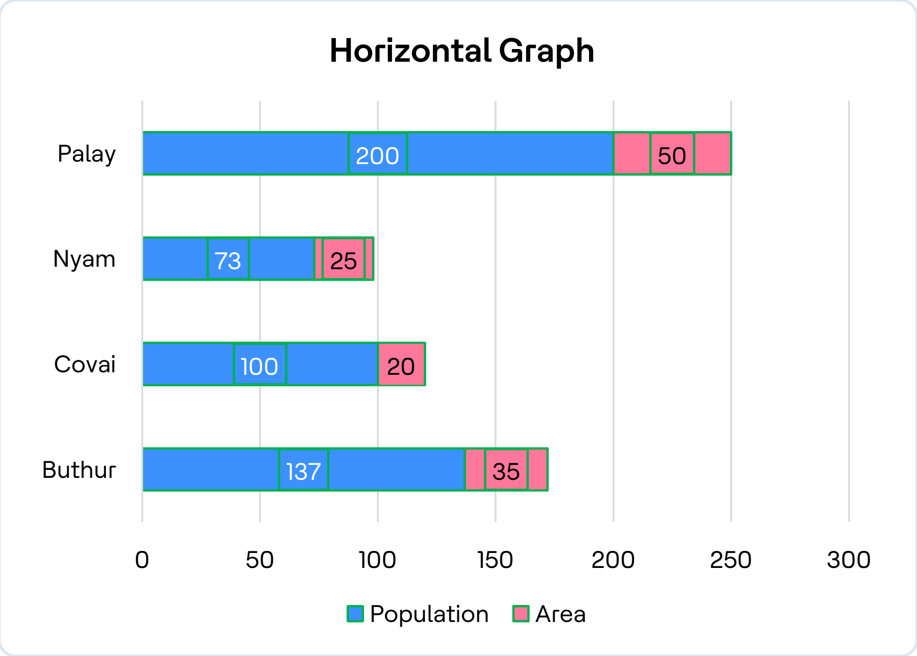


Figure 2: Graph actual output



Validated graph final result

Case 3

Figure 3 is a stream graph where all three layers of the graph need to be validated individually and to be reported as Validation Pass or Validation Fail. Similar kinds of graphs are commonly used in medical domains for measuring the average and maximum values. Manual validations of this kind of graph are very difficult for testers when the differences are incredibly minimal.

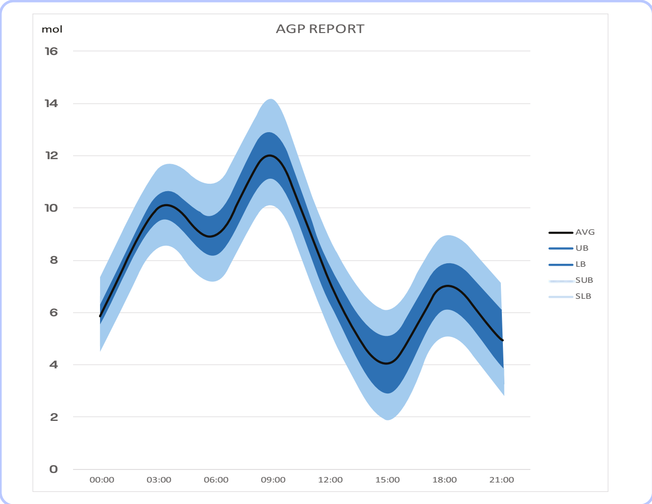
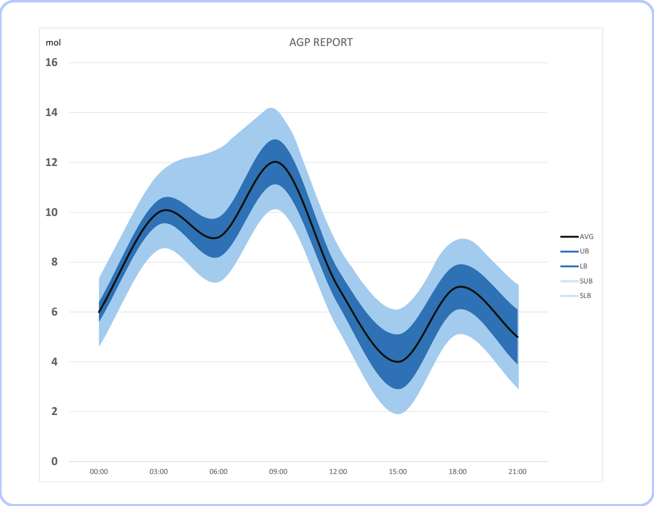


Figure 3: Standard graph image



Live graph image

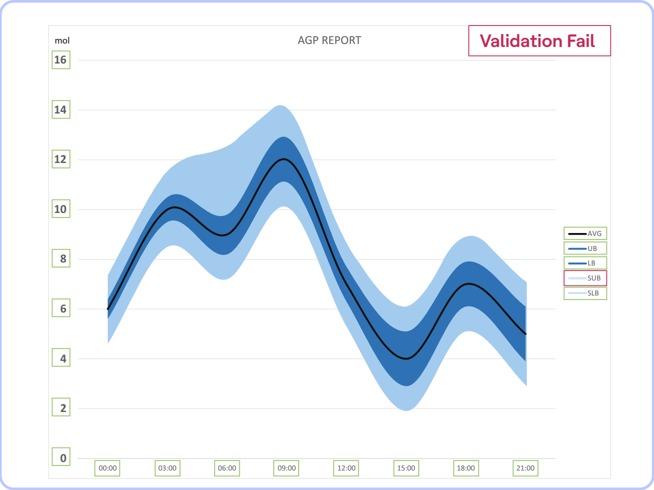


Figure 4: Validated live graph image

Benefits

1. Using AI, the end-to-end graph validation can be automated without any manual intervention
2. Can be integrated with any framework or work as a standalone
3. Helps validate the stream and stacked area graph
4. Graph validations can be performed for data values, text and colors
5. Reduce the testing cycle time and effort
6. Supports multi-dimensional images for validation

Conclusion

The proposed solution eliminates manual graph validation by automating the process in the testing cycle and providing results as Validation Pass or Validation Fail. It is developed using inhouse arithmetic techniques, deep learning and computer vision algorithms, and is highly customizable. Further, it works as a standalone solution or can be integrated into any existing framework. External data like text, color, x and y coordinates, shape and others is read from test case documents, databases or any similar sources. Complex graphs like bar, pie, histogram, stacked and stream areas are validated seamlessly with high accuracy and in less time.

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Authors information

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Hiransha M is an AI Engineer with 4 years of experience in developing data automation systems using machine learning, image processing, NLP and deep learning techniques. He also published a deep learning paper on "NSE Stock Market Prediction Using Deep Learning Models" in Elsevier in 2018.

Publications: NSE Stock Market Prediction Using Deep-Learning Models - ScienceDirect

Narender S

Narender S holds a Master's degree and has been in the software engineering industry for 15+ years. Healso has several years of experience in product engineering and sustenance engineering across domains. He has a strong understanding of the software automation process and has a proven track record of delivering results for enterprise clients.

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Srihari V has been in telecommunications and networking for the past 20 years. He has managed various testing teams and been creating next-gen solutions as value-adds for leading OEM clients. He is currently part of the Solutions team at HCLTech and generates AI-based solutions to support business needs.

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