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Smart Stick for Visually Impaired Persons

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Abstract: *Millions of people worldwide have visual impairments, and integrating them into society is a crucial ongoing goal. To support their quality of life, various guidance systems have been developed, often for specific purposes. However, these solutions can significantly enhance the mobility and safety of visually impaired individuals. To address this, a vision-based platform using Python and OpenCV library functionalities has been developed to recognize real-world objects indoors and outdoors. YOLO is a novel approach to object detection that has been used in the software. The image is transformed into a scan image for further interpretation of its contents. Efforts continue to support visually impaired individuals and enable their full participation in society. The detected image is scanned and fed into Tesseract OCR for conversion to text. Additionally, By using OCR and NLP (Natural Language Processing), blind persons can read newspapers.*

Keywords: YOLO, Open-CV, Tesseract OCR, TTS, Natural Language Processing.

I. INTRODUCTION

The visually impaired population is a significant segment of society, with estimates ranging in the tens of millions worldwide. Ensuring their integration into society is an important and ongoing objective, with considerable efforts being made to provide them with appropriate healthcare. To assist visually impaired individuals in leading normal lives, various guidance system techniques have been developed. Although these systems are frequently designed for specific tasks, they can significantly contribute to the mobility and safety of visually impaired individuals. The development of state-of-the-art guidance systems for visually impaired individuals is closely related to advances in image processing and computer vision, as well as the speed performance of devices and unit processors. During the indoor movement of visually impaired individuals, the assisted system's primary objective is to automatically detect and recognize objects or obstacles and provide an acoustic alert. The vision module proposed in this system is an integrated part of the platform designed to guide visually impaired individuals, but it can also be used independently of the integrated platform. The vision-based guidance system proposed has been designed, developed, and validated through experiments and iterative optimization. The module is compliant with the principle of developing a highly performance device that is cost effective and practical for usage. The module uses disruptive technology andallows for updating and inclusion of new functions.

II. LITERATURE SURVEY

The article by V. Tiponuţ et al. [1] highlights the advancements made in developing electronic travel aids (ETAs) as a substitute for traditional navigation tools used by the visually impaired.

The study discusses how ETA devices, based on sensor technology and signal processing, can enhance the mobility of blind users in unknown or dynamically changing environments. The paper presents theoretical and practical findings in the field of ETAs, including new concepts such as integrated environments for assisted movement, acoustical virtual reality, and bio- inspired solutions. The study concludes by summarizing the main outcomes and suggesting further developments in this area. Overall, the research shows that ETA devices have the potential to significantly improve the quality of life for the visually impaired by providing greater independence and mobility.

The article by Ayat A. Nada et al. [2] highlights that People with visual impairments require assistance to feel secure when travelling. This study develops a smart stick that increases mobility for persons who are blind or visually

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challenged. This makes use of various technologies, including laser, infrared, and ultrasonic. This suggests a low-cost, user-friendly, quick-response, lightweight, and energy-efficient smart stick that uses infrared technology. Within a two-meter range, two infrared sensors can identify the existence of stairs and other impediments in front of the user. This yields good accuracy, and the stick is able to identify every barrier. It then warns the user of the observed obstacles by speaking a spoken warning message through earbuds.

III. PROPOSED SYSTEM

The proposed work aims to facilitate the movement and a smart reader device for blind and visually impaired. The plan defines a Smart Stick for the identification of real-life indoor and outdoor objects to guide visually impaired people and also to read out anything written texts. Using Python and OpenCV library functions, the software is developed and eventually ported to a Raspberry Pi.

3.1 Block diagram

Overall, this block diagram in Fig 1 illustrates the integration of various components to create a smart stick for visually impaired persons. The combination of GPS, ultrasonic sensor, IR sensor, ESP Devkit, button, and Blynk enables the stick to provide location information, detect obstacles, and establish communication with a mobile app for enhanced safety and navigation assistance.

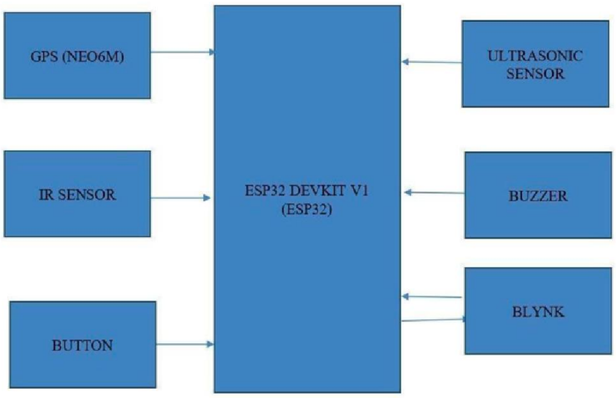

Fig 1 : Block Diagram

- GPS (Global Positioning System): The GPS module is used to determine the location of the smart stick user. It receives signals from multiple satellites to calculate the precise position coordinates. The GPS module provides latitude and longitude information, which can be used for navigation and tracking purposes.
- Ultrasonic Sensor: An ultrasonic sensor is used to detect obstacles in the path of the visually impaired person. It emits high-frequency sound waves and measures the time it takes for the waves to bounce back after hitting an object. By analysing the reflected waves, the sensor can estimate the distance to the obstacle. This information helps the user to navigate safely by detecting obstacles and avoiding collisions.
- ESP Devkit: The ESP Devkit is a microcontroller board that serves as the main control unit of the smart stick. It is equipped with Wi-Fi capabilities and can communicate with other devices over the internet. The ESP Devkit receives data from various sensors, processes it, and sends relevant information to the user interface or cloud platform.
- Button: The button acts as an input device that allows the visually impaired user to interact with the smart stick. It can be used for functions like turning on/off the stick, activating certain features, or switching between different modes of operation.
- IR Sensor: The IR sensor, or infrared sensor, is used to detect proximity or presence of objects within a short range. The IR sensor can be used in conjunction with the ultrasonic sensor to detect things or barriers that are closer to the user in the context of the smart stick.The IR sensor can be used in conjunction with the ultrasonic sensor to detect things or barriers that are closer to the user in the context of the smart stick.

- Blynk: Blynk is a platform that enables the creation of mobile applications to control and monitor connected devices. In the smart stick, Blynk can be utilized to develop a user-friendly mobile app that connects to the ESP Devkit. The app can display the information gathered from the GPS and sensors, providing real-time data about the user's location, detected obstacles, and other relevant details. The user can also control certain features of the smart stick through the app.

IV. SYSTEM REQUIREMENT

4.1 Software Requirement

A. OpenCV

OpenCV is used in smart stick for visually impaired persons to enhance its functionality by incorporating computer vision capabilities. Here are some ways OpenCV can be utilized.

Object Detection: OpenCV provides robust algorithms for object detection, such as the Haar cascade classifier or deep learning-based methods like YOLO (You Only Look Once) or SSD (Single Shot Multi Box Detector). These algorithms can be used to detect objects of interest, such as pedestrians, vehicles, or specific landmarks, which can help visually impaired users navigate their surroundings more safely.

Image Processing: OpenCV offers a wide range of image processing functions that can be used to enhance captured images or video frames. Techniques like image denoising, image enhancement, and image filtering can improve the quality of visual information for the user. Optical Character Recognition (OCR): OCR algorithms available in OpenCV can be utilized to extract text from captured images or video frames. This can be useful for reading signs, labels, or other text-based information for visually impaired users.

B. pyttxs3

The pyttsx3 library provides a simple and intuitive interface for converting text into speech. It supports multiple speech engines and platforms, allowing you to choose the one that suits your needs. By integrating pyttsx3 into the smart stick, you can convert textual information, such as navigation instructions, obstacle alerts, or text captured from images, into spoken words.

C. Yolo

YOLO is a state-of-the-art object detection algorithm that can identify and locate multiple objects within an image or video frame in real-time. By integrating YOLO into the smart stick, the device can analyse the input from a camera or sensor and detect various objects in the user's environment. This can include obstacles, pedestrians, vehicles, or other relevant objects. YOLO's object detection output can be further processed and relayed to the user through text- to-speech (TTS) capabilities. The smart stick can convert the detected objects into spoken words, providing audible cues about the objects present in the user's surroundings.

D. Tesseract

Tesseract OCR can extract text from images captured by the smart stick's camera. Once the text is extracted, it can be converted into speech using text-to-speech (TTS) technology. This allows blind users to listen to the text read aloud, providing them with access to printed information in their surroundings.

E. Tkinter

Tkinter can be used to design a user interface that provides audio feedback for blind users. Instead of relying on visual cues, the interface can use text-to-speech (TTS) capabilities to convert textual information into spoken words. For example, buttons or menu options can be labelled with text, and when selected or interacted with, the corresponding text can be read aloud to the user using TTS.

4.2 Hardware Requirement

Components	specification	Description
1)Raspberry pi 4B	The **Raspberry Pi 4 Model B** has a 1.5 GHz 64-bit quad core ARMCortexA72 processor, on-board 802.11ac Wi-Fi full Ethernet (throughput not limited), two USB 2.0 ports, two USB 3.0 ports, 1–8 GB of RAM, and dual-monitor support via a pair of micro HDMI (HDMI Type D) ports for up to 4K resolution.	The Raspberry Pi 4B features a quad-core ARM Cortex-A72 processor, which provides ample processing power to handle various tasks involved in a smart stick, such as image processing, object detection, and running complex algorithms.
2)Infrared Sensor	• Operating Voltage is 3.3 ~ 5 VDC. • Distance Measuring Range 2	The IR sensor can be used to detect obstacles in the path of the blind user.
3) Node MCU	• Operating Voltage: 3.3V. • Input Voltage: 7-12V. • Flash Memory: 4 MB. • SRAM: 64 KB. • Clock Speed: 80 MHz..	The Node MCU has built-in Wi-Fi capabilities, allowing the smart stick to connect to the internet and communicate with other devices or online services.
4) Buzzer	• Working voltage: 3.5-5.5V. • Working current: <25mA. • PCB Dimension: 1.85 x 1.5 cm (L x W). • Tone Generation Range is 1.5 ~ 2.5kHz.	The Buzzer can be used to provide audio feedback when an obstacle is detected. When the smart stick's sensors (such as ultrasonic or infrared sensors) detect an obstacle within a certain range, the buzzer can emit a sound to alert the user about the presence of the obstacle.
5) GPS Module	• GPS modules provide position updates at a specific rate, usually measured in Hz (Hertz). Common update rates range from 1 Hz to 10 Hz, indicating the number of position updates per second. •GPS modules usually operate at 3.3V or 5V DC power supply voltages. • GPS module requires power of 100mW.	The GPS module can determine the user's precise location coordinates using signals received from satellites. This information can be used to provide the user with their current location, which can be helpful for orientation, navigation, or sharing location information with others.

Table 1 : Hardware Requirements

V. METHODOLOGY/IMPLEMENTATION

5.1 Hardware Implementation

The Smart Bind Stick is a device that incorporates an ultrasonic sensor, IR sensor, buzzer, button, and GPS module. When the button is pressed, the GPS module will send the location data to the Blynk application. The ultrasonic sensor is used to detect the distance between the Smart Bind Stick and an obstacle. It emits high-frequency sound waves and then measures the time it takes for the waves to bounce back to the sensor. Based on this time measurement, the sensor can calculate the distance to the obstacle.

The IR sensor is used to detect the presence of an object in front of the Smart Bind Stick. It emits infrared light and then measures the reflection of the light off an object. Based on the amount of reflected light, the sensor can determine

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whether there is an object in front of it. The buzzer is used to provide audio feedback to the user. It can be programmed to emit different tones and patterns depending on the situation. For example, it can beep when an obstacle is detected or when the button is pressed.

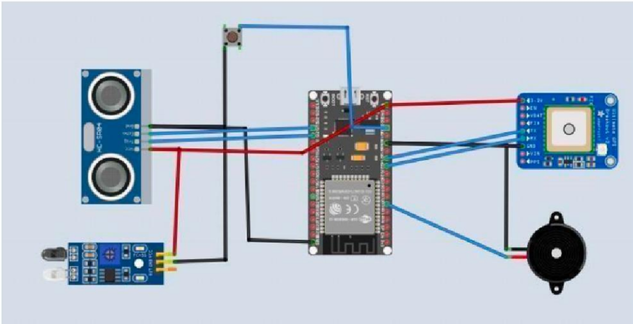

Fig 2 : Circuit Diagram

The button is used to trigger the GPS module to send the location data to the Blynk application. When the button is pressed, it sends a signal to the GPS module, which then retrieves the location data from its internal GPS receiver. The GPS module then sends this data to the Blynk application via a wireless connection.

In the Smart Stick, the button is used to trigger the GPS module to send location data to the Blynk application. When the user presses the button, it sends a signal to the GPS module, which then retrieves the location data from its internal GPS receiver. The GPS module then sends this data to the Blynk application, which can display the location on a map or perform other actions based on the user's preferences. The button can also be used for other functions, such as turning on/off the device or switching between modes of operation.

Blynk App Interface

Fig 3 : Blynk Mobile Application

The Blynk application as shown in Fig 3 is a smartphone app that allows users to control and monitor their IoT devices. When the location data is received by the app, it can display the location on a map or perform other actions based on the user's preferences.

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Software Implementation

1. Object Detection

Flow Chart of Object Detection

The raspberry pi camera captures the image and it divides the image into a 13×13 grid of cells.

The size of these 169 cells vary depending on the size of the input. For a 416×416 input size that we used in our experiments, the cell size was 32×32. Each cell is then responsible for predicting a number of boxes in the image.

For each bounding box, the network also predicts the confidence that the bounding box actually encloses an object, and the probability of the enclosed object being a particular class. Most of these bounding boxes are eliminated because their confidence is low or because they are enclosing the same object as another bounding box with very high confidence score. This technique is called non-maximum suppression.

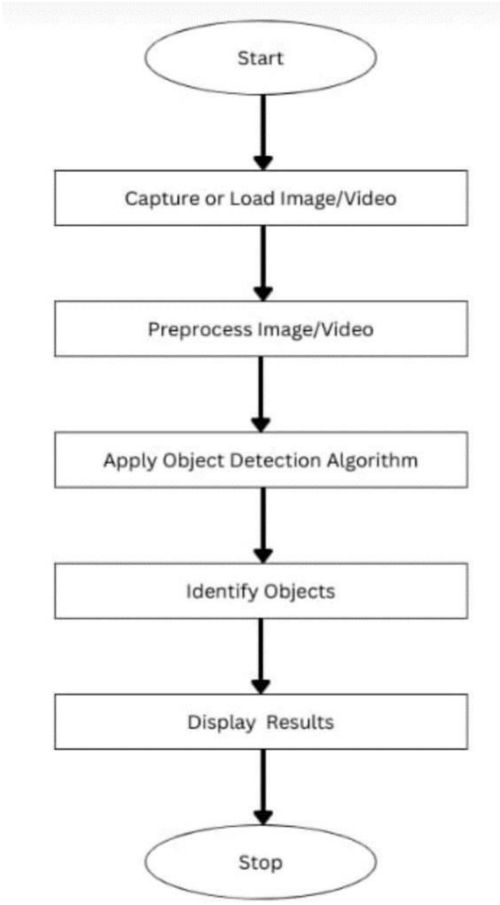

Fig 4 : Flow Chart Of Object Detection

Then download the models like yolov3.weights file which contains the pre-trained networks weights, yolov3.cfg file which contains the network configuration and coco. Names file which contains the 80 different class names used in the COCO dataset

Initialize the parameters which generates bounding boxes as the predicted detection outputs. Every predicted box is associated with a confidence score.

The coco. Names contains classes all the objects for which the model was trained and loading of network can be done in two parts they are yolov3.weights which are pre- trained weights and yolov3.cfg which is the configuration file and processing of each frame is done along by getting the names of output layers then it will identify the objects and will display the results.

2. Road sign detection

The detection system then processes frames until a sign candidate is found with an associated shape. This candidate is finally passes to an external sign classifier.

The detection unit, which is the proposed method, can be broken down further. This method will be presented in the same order as the flow of data through the sign detector.

The pre-processing and segmentation will be covered first.

Then classification stage in this approach is split into two subgroups which could operate independently but together add redundancy; SVM classification and Binary Image Testing. These then converge into the sub-section which deals with tracking of the signs in images, and finally the decision on shape and region which would be passed.

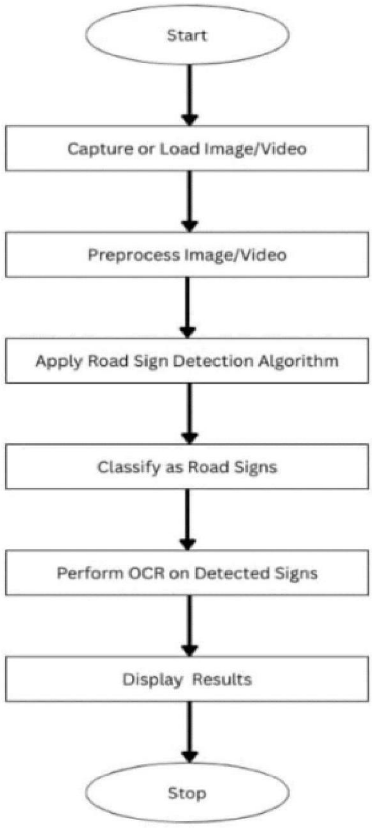

Fig 5 : Flow Chart of Road Sign Detection

3. Text Recognition

Image Capturing: First step is to capture an image from the document or book and the document or is placed under the camera which is help to capture an image from the document or book. The camera used to capture an image is PC camera.

Image Pre -processing: Image pre-processing is to remove unwanted noise in the image by applying appropriate threshold. It is use for correcting skew angles, sharpening of image, thresholding and segmentation.

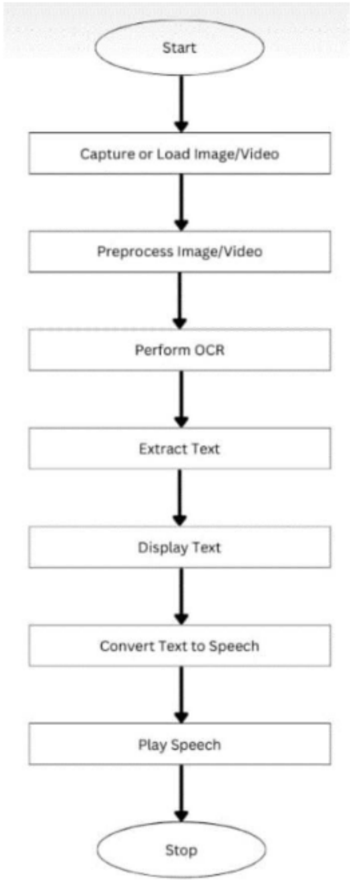

Fig 6 : Flow Chart Of Text Recognition

Text Extraction: In the Project the use tesseract ocr engine which is used to extract the recognized text.

Text to speech: After extracting the text the text will be convert into speech. The text to speech synthesizer is used to convert text into speech. At last stage the speech output will get through.

VI. RESULTS

The proposed system using Tesseract-OCR , the system is able to read and recognize text in images and the text is displayed and converted into speech in Fig 7.

Fig 7 : Output of Text to Speech

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By implementing YOLO, the proposed system is able to detect the objects like Scissors, Bottle,Banana as shown in fig 8 and fig 9 .

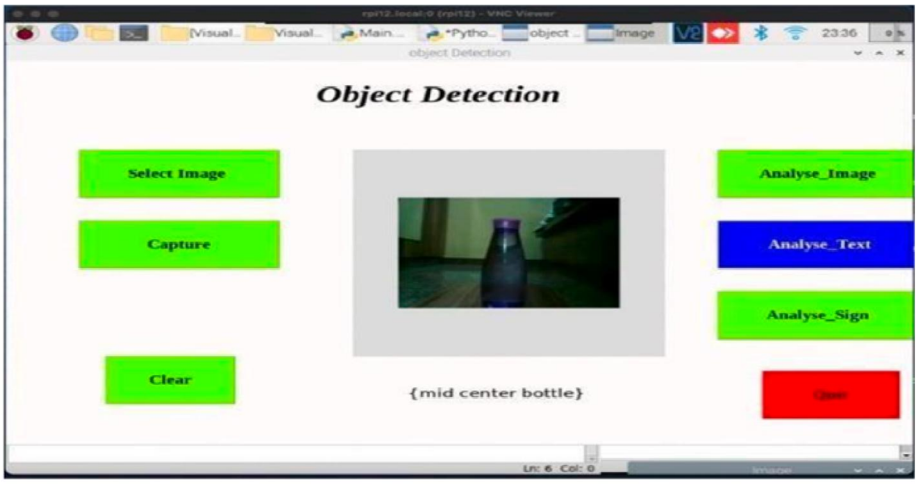

Fig 8 : Bottle Detection

The image of the bottle was captured in evening .The raspberry pi was able to capture the image and was able to recognize the Object as a bottle which is placed in middle position upto 5 ft as Shown in Fig 8 .

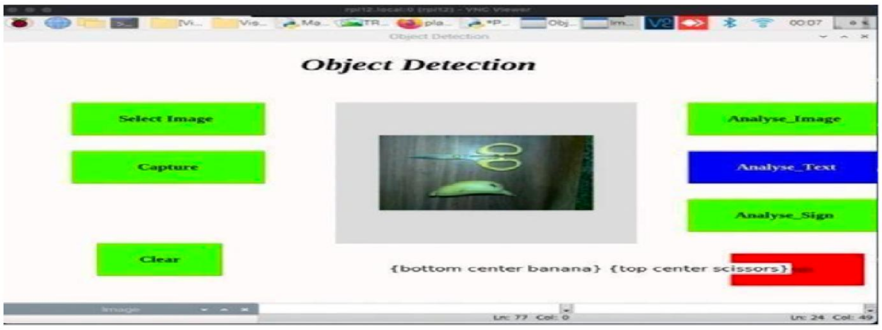

Fig 9 : Scissors and Banana Detection

The image was captured at Day Bright light. The raspberry pi camera was able to capture the image Shown in Fig 9. There are two objects one is scissor the other one is banana. The raspberry pi camera was able to recognize the banana upto a distance of 3m and the distance of scissor up to 3m. As the size of the object increases the detection will be more precise.

The road Signs are detected and once the road sign is detected then smart stick provides audio to the user to convey the type of sign and other relevant information and the output is shown in Fig 10 .

Fig 10 : Speed Limit Sign Detection

The image was captured at Day bright light. The raspberry pi camera was able to capture the image and was able to recognize the road sign as Speed Limit (20 km/h)upto a distance of 5ft as shown in Fig 5.6.As the size of the object increases the detection will be more precise.

Table 2 depicts the analysis of detected objects based on the distance ,Depending upon the object size the distance at which the object detected can be measured and it leads to the accuracy of 87% for larger objects and 65% for the smaller objects.

Items	Dimensions	Distance From Items												
	(0CMXOCM)	40cm	60cm	80cm	1m	1.5m	2m	3m	4m	10m	20m	30m	40m	50m above
Scissors	(13CMX15CM)	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
Bottle	(25.3CMX6.53CM)	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
Book	(19.7CMX13.2CM)	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Laptop	(35.92CMX20.34CM)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗
Dining Table	(76CMX152CM)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
Car	(383.7CMX174.2CM)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

VI. CONCLUSION

A Smart stick for visually impaired persons can significantly improve their mobility and independence. With the use of advanced technologies such as sensors, GPS, and voice assistants, these smart sticks can detect obstacles and provide real-time guidance to the user. They can also offer features such as object recognition, facial recognition, and text-to-speech conversion. Overall, the smart stick for visually impaired persons is a promising technology that has the potential to enhance the quality of life for individuals with visual impairments. However, it is important to note that further research and development are necessary to address any limitations and ensure that the technology is both effective and accessible to all users.

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