Smart Innovation, Systems and Technologies 312

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IOT with Smart Systems

Proceedings of ICTIS 2022, Volume 2

KES International

Springer

Smart Innovation, Systems and Technologies

Volume 312

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ISSN 2190-3018 ISSN 2190-3026 (electronic)
Smart Innovation, Systems and Technologies
ISBN 978-981-19-3574-9 ISBN 978-981-19-3575-6 (eBook)
https://doi.org/10.1007/978-981-19-3575-6

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

The Sixth International Conference on Information and Communication Technology for Intelligent Systems (ICTIS 2022) targets state of the art as well as emerging topics pertaining to information and communication technologies (ICTs) and effective strategies for its implementation for engineering and intelligent applications.

The conference is anticipated to attract a large number of high-quality submissions, stimulate the cutting-edge research discussions among many academic pioneering researchers, scientists, industrial engineers, students from all around the world, and provide a forum to researcher; propose new technologies, share their experiences, and discuss future solutions for design infrastructure for ICT; provide a common platform for academic pioneering researchers, scientists, engineers, and students to share their views and achievements; enrich technocrats and academicians by presenting their innovative and constructive ideas; focus on innovative issues at international level by bringing together the experts from different countries.

The conference was held during April 22–23, 2022, physically on April 22, 2022, at Hotel Pride Plaza, Bodakdev, Ahmedabad, and digitally on April 23, 2022, platform: Zoom, and was organized by Global Knowledge Research Foundation in collaboration with KCCI and IFIP INTERYIT.

Research submissions in various advanced technology areas were received, and after a rigorous peer review process with the help of program committee members and external reviewer, 150 papers were accepted with an acceptance rate of 16%. All 150 papers of the conference are accommodated in two volumes, and also, papers in the book comprise authors from eight countries.

This event success was possible only with the help and support of our team and organizations. With immense pleasure and honor, we would like to express our sincere thanks to the authors for their remarkable contributions, all the technical program committee members for their time and expertise in reviewing the papers within a very tight schedule, and the publisher Springer for their professional help.

We are overwhelmed by our distinguished scholars and appreciate them for accepting our invitation to join us through the virtual platform and deliver keynote speeches and technical session chairs for analyzing the research work presented by

the researchers. Most importantly, we are also grateful to our local support team for their hard work for the conference.

Hatfield, UK — Jyoti Choudrie
Pune, India — Parikshit Mahalle
Serdang, Malaysia — Thinagaran Perumal
Ahmedabad, India — Amit Joshi

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About the Editors

Prof. Jyoti Choudrie is Professor of Information Systems in Hertfordshire Business School, Management, Leadership and Organization (MLO) department where she previously led the Systems Management Research Unit (SyMRU) and currently is a convenor for the Global Work, Economy and Digital Inclusion group. She is also Editor-in-Chief for Information, Technology and People journal (An Association of Business School 3 grade journal). In terms of research, Professor Choudrie is known as the Broadband and Digital Inclusion expert in University of Hertfordshire, which was also the case in Brunel University. To ensure her research is widely disseminated, Professor Choudrie co-edited a Routledge research monograph with Prof. C. Middleton: The Management of Broadband Technology Innovation and completed a research monograph published by Routledge Publishing and focused on social inclusion along with Dr. Sherah Kurnia and Dr. Panayiota Tsatsou titled: Social Inclusion and Usability of ICT-Enabled Services. She also works with Age (UK) Hertfordshire, Hertfordshire County Council and Southend YMCA where she is undertaking a Knowledge Transfer Partnership project investigating the role of Online Social Networks (OSN). Finally, she is focused on artificial intelligence (AI) applications in organizations and society alike, which accounts for her interests in OSN, machine and deep learning. She has been a keynote speaker for the International Congress of Information and Communication Technologies, Digital Britain conferences and supervises doctoral students drawn from around the globe. Presently, she is seeking three to four doctoral students who would want to research Ai in society and organizations alike.

Dr. Parikshit Mahalle is a senior member IEEE and is Professor and Head of Department of Artificial Intelligence and Data Science at Vishwakarma Institute of Information Technology, Pune, India. He has his Ph.D from Aalborg University, Denmark, and continued as Post Doc Researcher. He has 21 + years of teaching and research experience. He is a member of Board of Studies in Computer Engineering SPPU, Ex-Chairman Board of Studies (Information Technology)—SPPU and various

Universities. He has 9 patents, 200+ research publications (citations-1873, H index-19) and authored/edited 30+ books with Springer, CRC Press, Cambridge University Press, etc. He is the editor in chief for IGI Global—International Journal of Rough Sets and Data Analysis, Associate Editor for IGI Global—International Journal of Synthetic Emotions, Inter-science International Journal of Grid and Utility Computing, member—Editorial Review Board for IGI Global—International Journal of Ambient Computing and Intelligence. His research interests are algorithms, Internet of things, identity management and security. He has delivered 200 plus lectures at national and international levels.

Dr. Thinagaran Perumal received his B.Eng. in Computer and Communication System Engineering from Universiti Putra Malaysia in 2003. He completed his M.Sc. and Ph.D. Smart Technologies and Robotics from the same university in 2006 and 2011, respectively. Currently, he is appointed as Senior Lecturer at the Department of Computer Science, Faculty of Computer Science and Information Technology, Universiti Putra Malaysia. He is also currently appointed as Head of Cyber-Physical Systems in the university and also been elected as Chair of IEEE Consumer Electronics Society Malaysia Chapter. Dr. Thinagaran Perumal is the recipient of 2014 IEEE Early Career Award from IEEE Consumer Electronics Society for his pioneering contribution in the field of consumer electronics His research interests are toward interoperability aspects of smart homes and Internet of things (IoT), wearable computing and cyber-physical systems. His recent research activities include proactive architecture for IoT systems; development of the cognitive IoT frameworks for smart homes and wearable devices for rehabilitation purposes. He is an active member of IEEE Consumer Electronics Society and its Future Directions Committee on Internet of Things. He has been invited to give several keynote lectures and plenary talk on Internet of things in various institutions and organizations internationally.

Dr. Amit Joshi is currently Director of Global Knowledge Research Foundation and also an entrepreneur and researcher who has completed his graduation (B.Tech.) in Information Technology and M.Tech. in Computer Science and Engineering and completed his research in the areas of cloud computing and cryptography in medical imaging with a focus on analysis of the current government strategies and world forums needs in different sectors on security purposes. He has an experience of around ten years in academic and industry in prestigious organizations. He is an active member of ACM, IEEE, CSI, AMIE, IACSIT-Singapore, IDES, ACEEE, NPA and many other professional societies. Further currently, he is also the International Chair of InterYIT at International Federation of Information Processing (IFIP, Austria). He has presented and published more than 50 papers in National and International Journals/Conferences of IEEE and ACM. He has also edited more than 20 books which are published by Springer, ACM and other reputed publishers. He has also organized more than 40 national and international conferences and workshops through ACM, Springer, IEEE across five countries including India, UK, Thailand and Europe.

Chapter 1
Hand Gesture-Controlled Simulated Mouse Using Computer Vision

Sarvesh Waghmare

Abstract Hand gestures are an essential component in our everyday lives for nodding and conversation. At this time, human–computer interactions have so many strategies. However, this type of interaction with a computer could create revolutions by not using complicated hardware. Using this technology, any individual can communicate with a computer in a more natural manner by simply using his/her hand to navigate throughout the computer screen. By virtually displaying our hand in front of the camera, we will be able to move the cursor and control our system. All sorts of human beings can use this system effectively and in an easy way to control computer systems and numerous gadgets. Based upon the above concept, this paper is staged. This paper clarifies the methodologies for providing numerous steps in color detection, and vision-based strategies for identifying a hand and controlling the virtual mouse.

Keywords Computer vision · OpenCV · MediaPipe · HCI (Human–computer interactions)

1.1 Introduction

Everyone needs technology. Everyone is becoming tech-friendly; technology is an essential part of every day-to-day life. So here, to provide this need, computers play a very important role. Computers give solutions to every person of any age and in any area of industrialized society. Why are we interacting with computers? To make our work and lifestyle simpler, isn't it? Human–computer interaction (HCI) has to turn out to be a very critical subject matter for research.

Today, we have a computer mouse as an input device that is used by us to communicate with computers, but there are some limitations to the mouse and its accuracy. Regardless of how much the mouse's accuracy has improved recently, a mouse is made up of hardware elements, so there may be some issues, such as the click not

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J. Choudrie et al. (eds.), *IOT with Smart Systems*, Smart Innovation, Systems and Technologies 312, https://doi.org/10.1007/978-981-19-3575-6_1

working or having an endurance time limit. Furthermore, because the mouse is a hardware tool, it has a limited life span, and after that time, we must replace it for optimum functionality.

As a generation increases, the whole lot will become virtualized, together with hand recognition and speech recognition. Hand gestures are a very effective and popular method of communication among people. In fact, in our everyday lives, hand gestures are frequently used. Hand gestures are deeply rooted in our attitude toward expressing one's thoughts to each other, so this form of the interplay among people and computing gadgets may be executed with the aid of hand gestures for communication.

The biggest hassle is that the way to make hand gestures understood with the aid of computer systems is through (1) data gloves or (2) vision-based approaches. This paper presents a vision-based method for hitting upon detection of hand gestures and executing some features, which consist of left clicks and right clicks, that are carried out by a physical computer mouse. Then, using computer vision, I created a user interface in which user can perform right and left clicks with hand gestures. The system needs to be optimized to fulfill the requirements, which include accuracy and precision.

Hand recognition, which I will be able to discuss during this paper, is powered by OpenCV. OpenCV is a library of programming functions primarily aimed at real-time computer vision. That is used for capturing images from a webcam. Thus, once the technology is developed, things like professional, smoother software are created and developed for simple use of this technique. Artificial intelligence and machine learning are trending technologies that facilitate the simple operation of systems with no human interactions. So, in this case, this system is additionally a part of the technologies that will help us work a lot more efficiently.

This system allows the user to control the cursor with the help of hand gestures, and the system's webcam is in use for input monitoring of hand gestures. Here, OpenCV is used due to its package known as video capture, that is used to capture statistical data from a live video in a time-frame-by-frame manner.

1.2 Existing Systems

As per the previous studies, most of them assign the cursor pointer as a palm centroid by using many algorithms, such as convex hull algorithms and so on, and fingers are assigned as commands for that cursor, like right clicking and left clicking. The main drawback of the system is that if any program is on the top of the screen, hand gestures are not mapped like a mouse, so we have to take our hand in an upwards direction to meet our cursor (centroid of palm) and so that our commanding system, which are fingers, is above the screen. So, we can navigate in the top section but cannot give a command to the system as our fingers are out of the action area [1–3].

There are some problems like some individuals forgetting to form the worst-case scenario of multiple identifications of a target.

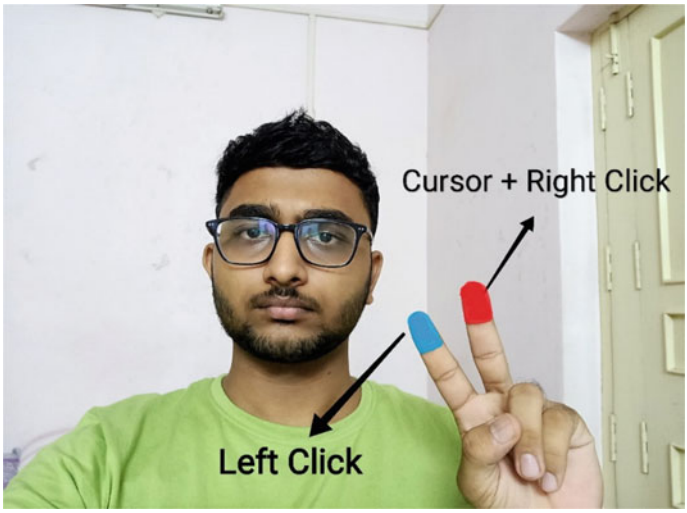

Fig. 1.1 The left click is performed with the forefinger, while the middle finger serves as the cursor pointer and the right click is performed with the middle finger

1.3 Proposed Solution

As per the drawback, I want to provide a solution as I will assign a cursor pointer to my hand's topmost part, which is the middle finger, and assign the middle finger as right clicking and the forefinger as left clicking. Because in our hands, only the thumb, forefinger, and middle fingers are more dominant than the ring and little finger.

As multiple identifications may occur, most importantly, the approach should be more lenient toward a particular color detection. Hence, in this paper, I am using red and blue color caps for finger identification (see Fig. 1.1).

1.4 Requirements for Proposed System

To achieve this project, I am using OpenCV, which is a Python library mainly aimed toward real-time video capturing and processing (computer vision). An "import cv2" is used to import the OpenCV library into the code. It additionally makes use of NumPy, a Python library primarily aimed toward high-level mathematical operations on arrays and matrices [4, 5].

Table 1.1 mentions the minimum requirements for doing this project. This environment of specifications is very important to achieve good results and prevent some of the runtime errors and drawbacks from previous projects.

Table 1.1 Requirements

Item	Specification
Microsoft Window	Support architecture: -32bit (×86) -64bit (×86)
OpenCV	OpenCV v4.5.1
MediaPipe	Medialise v0.8.5
PyCharm	PyCharm v2021.1.1
OS	Windows 7 or above/Ubuntu OS
Ram	4 GB or above
Camera	12 MP or above
CPU	i3-3rd gen or above/AMD zen2 or above
GPU	Any Nvidia/AMD/Intel graphics

1.5 Methodology

In the methodology, the method of each factor is described in Fig. 1.2 step by step, and its running can be validated (see Fig. 1.2).

1.5.1 Video Acquisition

Video acquisition steps are explained here for video capturing and several other video operations. Videos are captured from system default regular webcam at resolution 1920 × 1080 with fps of 40 (default setting) [2, 6].

Real-Time Video Capturing An accurate interactive device constantly includes a few sensors that give the best inputs to the device. Right here, a webcam is used to capture actual-time video at constant frame rates and resolutions. After taking pictures of actual-time video inputs, snapshots are extracted from video frame by frame using means and processed in line with the RGB shade layout of a matrix (m × n) in which every detail includes a (1 × 3) matrix of red, a matrix of green, and a matrix of blue channels. Hence, this is the main reason behind choosing finger colors of blue and red for the forefinger and middle finger, respectively, for detection. RGB colors are dominating colors and are also called the "mother" of all colors because, using their combinations, all colors are formed [7].

For webcam input: cap = cv2.VideoCapture(0)

Flipping of Video After a while, during video acquisition, if we tend to move our hand toward one direction, let us say left, the image of the hand moves toward the opposite direction to the movement of the hand. In this case, the hand moves toward the right and vice versa. Once the video is previewed, it is determined that the video

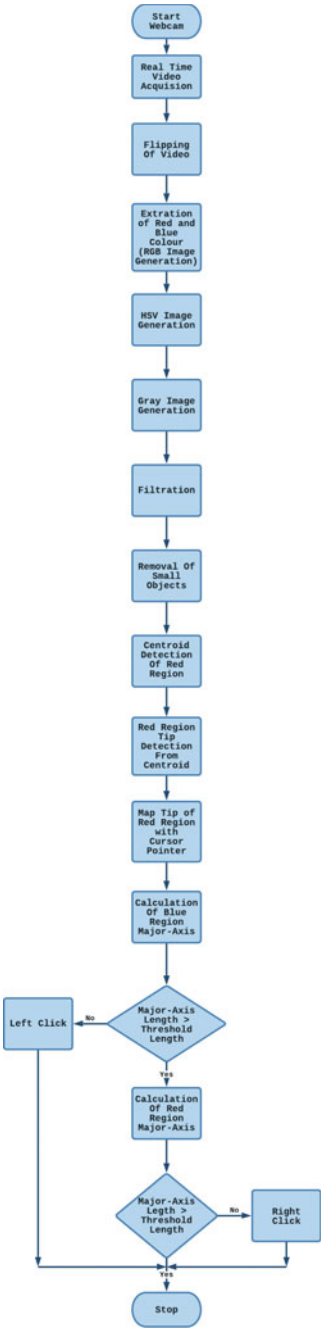

Fig. 1.2 The process is depicted in a flowchart

is horizontally inverted. So, it is necessary to flip the image horizontally. That is achieved in OpenCV using the function of flipping [1].

BGR (Blue, Green, Red) to RGB (Red, Green, Blue) image.
image = cv2.cvtColor(cv2.flip(image,1), cv2.COLOR_BGR2RGB).

1.5.2 Color Conversions

As OpenCV supports image conversions, we have to do things like RGB Image → HSV Image → Gray Scale Image for the identification of the targeted object. Most importantly, the model that is developed must have a specific color detection. If we miss this step or misplace it, we are going to have problems. To get around this, we have got multiple ways to do the color variation and detection properly using HSV Color Code. Using these strategies, the system may be developed for higher usage without any problems [8].

To achieve our desired colorations, we needed to detect red and blue colors in the flipped image. A subtractive approach is employed wherever a grayscale image is generated once the HSV image from the flipped image is subtracted from the red and blue band images individually. The result we tend to get is that the red and blue additives of the images within the grayscale coloration version were obtained and were able to subtract the background colors, extra fingers, and skin color visible in the image.

1.5.3 Noise

Noise is a very important and crucial factor in any computer vision system, and that needs to be pointed out clearly. Because of dust or other issues, little undesirable errors emerge when scanning images.

Filtration After capturing the red and blue additives from the photograph, a few pixels are scattered, which creates salt and pepper-like noise. Hence, to get rid of those effects, the OpenCV Median Filter is in use [3].

Median Filtering The function "cv2.medianBlur()" finds the median of all pixels below the kernel window and uses that value to replace the middle pixel. This works particularly well for getting rid of the salt and pepper sound. One exciting feature of the term is that the filtered value for critical details in Gaussian and field filters can be a value that is not present in the original image. In median filtering, however, this is not the case because the center detail is often affected by the approach of a few pixels inside the image. Noise is successfully reduced as a result of this. The kernel must be an odd positive integer in size [5].

Syntax: (median = cv2.medianBlur(img))

Unwanted Objects from Image Because the system uses a webcam as an input, numerous issues arise as a result of the image's environment. When attempting to import our essential packages, this is a critical factor. NumPy will be used for numeric processing, while "import cv2" will be used for OpenCV connectivity [9].

The function "is contour bad" is then defined. This function takes over implementation and provides the criteria for marking a contour as "bad" and removing it from the image.

1.5.4 Cursor Mapping Using Centroid of Red Part

Now, the image is ready after the use of numerous steps listed above, but the mapping of the cursor pointer is still pending. Consequently, the finger position in the image and the cursor relationships need to be set up. First of all, the labeled matrix is solved via the approach of the use of NumPy. In this, calculations are executed on the concept of major-axis length for the red part of a finger. Mathematically, centroid $(\overline{X}, \overline{Y})$ is also calculated with the help of segmenting the colored objects from the image from the underneath equation [10, 11].

$$\text{Centroid} : \left\{ \overline{X} = \sum_{i=0}^{k} x_i / K, \overline{Y} = \sum_{i=0}^{k} y_i / K \right\} \tag{1.1}$$

where X_i and Y_i, $\overline{X}$ and $\overline{Y}$ are co-ordinates of *i*th pixel and K denotes numbers of pixel in the image [11].

Now as centroid is calculated for calculation of tip of red part of object, we have to add Y_i in centroid.

$$\text{Cursor Tip} : \left\{ X^t = \overline{X}, Y^t = \overline{Y} + 2 \sum_{i=0}^{K/2} y_i / K \right\} \tag{1.2}$$

where X^t, Y^t are co-ordinates of pixel which act as tip of object like a cursor and K denotes numbers of pixel present in image (Fig. 1.3).

1.5.5 Perform Different Operations

In this, left click is assigned to the blue color, which is the forefinger, and right click is assigned to the red color, which is the middle finger. At the initial stage of image acquisition, when the hand is opened completely, it is at its maximum size of a palm, and this length can be calculated as its max/major length. This information, at the initial stage of image acquisition, is used as the main or mother image of this project.

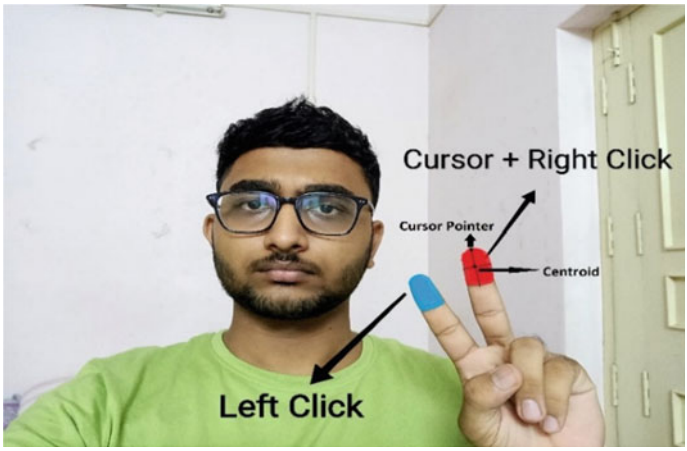

Fig. 1.3 The tip of the red part is used as a cursor pointer, using the red part's centroid as the origin

Right Click Based on the mother image, it got information about the middle finger's major length, and, by folding the middle finger, its defined threshold changes; hence, the right click will perform.

$$\text{Condition : Right Click} = \text{Major Axis Length} < \text{Threshold}$$

Left Click Based on the mother image, it got information about the forefinger's major length and, by folding the forefinger, its defined threshold changes; hence, the left click will perform.

$$\text{Condition : Left Click} = \text{Major Axis Length} < \text{Threshold}$$

1.6 Further Development

By using this information, one can further develop.

Real-Time Operation: Pause/Play.
Real-Time Operation: Page Up/Down.
Real-Time Operation: Tab Shifting.
Real-Time Operation: Dragging/Dropping.

Many applications for people with disabilities could benefit from gesture recognition. With the help of advanced graphical user interface software, we can create a graphical user interface software fused with this technology and amalgamate that interface with extraordinarily high-profile cameras that will control machine

learning robots. With the further refinement of the videos, we will be in a position to take advantage of an advanced GUI. By that time, this autonomous robot might be deployed as a home service robot, a complex operation managing robot, or a defense mission robot.

The most well-known application of gestures is in the field of digital painting, where users may paint in 3-D structures and have their artwork appear in 3-D. This is incredible. Those concepts could also be used in virtual reality, augmented reality, and gaming. Games based on hand movements, such as snake games and running games, can be created.

1.7 Conclusion

Computer vision and machine learning techniques aid in the development of human–computer interactions based on perceived standard colors extracted from visual input. The successful and unique dis-jointing of standard color is a crucial step toward accomplishing this goal. This paper is very effective in available gesture cursor operation with machine learning, computer vision-based color recognition, and image segmentation with the aid of marking those circumstances.

The goal of this project was to create a system that could collect images and perform mouse functions, such as moving the mouse pointer, dragging and clicking, and using colored caps on the fingers. The OpenCV, MediaPipe, and NumPy environments were used to create this system. Since vision-based technology is far less expensive, it is replacing contact technology. We like to employ a virtual digital camera that is already built into digital devices with this technology. We feel that this technology has a bright future in human–computer interaction (HCI) systems after doing this research. Robotics, medical equipment, laptop games, and other applications will all benefit from it.

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Chapter 2
E-Commerce Web Portal Using Full-Stack Open-Source Technologies

Archit Tiwari and Shalini Goel

Abstract E-commerce applications are tools for accessing the Internet as well as purchasing products and services. People nowadays do not prefer to go out to buy; instead, they prefer the goods and services to be delivered at their place. Such technologies are evolving day by day as a huge advancement of technology is observed with a rapid pace. This paper offers a fresh perspective on how open-source technologies can be used in building e-commerce platforms, thereby reducing various costs such as licensing fees of enterprise software and tools. This full-stack web application enables the user to buy products from an online platform. Apart from buying, the user is provided with a wide variety of features such as selecting products of a particular category, filtering the products on the basis of color, size, and many other features that make this application more user friendly. Also, the data which is received from the front end or posted on the front end is in an unstructured json format. It is tough to store such data in a tabular format. So as to store such kind of unstructured data, we need a NoSQL database, i.e., MongoDB.

Keywords Open-source technologies · NoSQL · RDBMS · Full-stack web application · Relational databases · Node.js · React.js · MongoDB

2.1 Introduction

Internet and computer are the two most important and widely used things these days. Online work is easier than offline work, and we can save more time. People prefer to shop for goods and services online rather than going to markets. The scope of online business has expanded as a result of this changing trend. The number of people who want to sell their goods and services online has skyrocketed. Over the last five years, online buying has exploded. While e-commerce was just getting started a decade ago, consumers are now demanding more convenience through online shopping. When a customer uses an Internet-enabled mobile device (such as a smartphone or

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J. Choudrie et al. (eds.), *IOT with Smart Systems*, Smart Innovation, Systems and Technologies 312, https://doi.org/10.1007/978-981-19-3575-6_2

tablet) to explore and browse a store or brand, this is known as mobile shopping. Smartphone shopping affects 90% of purchase behavior among consumers who use mobile devices. Most of the people are able to buy things by making use of their smart phones. The personal relationship that a consumer has with their mobile device is an extra issue that necessitates merchants developing a fundamentally different strategy to satisfy this type of mobile shopper. The consumer's goal is not just to buy the goods, but also to learn about it and find out what other options are available in those areas. Recently, e-commerce merchants have recognized the expanding market for mobile-based shopping and have provided customers with an optimized and distinctive mobile buying experience. In order to develop full-stack web applications, organizations use various licensed software. Organizations have to pay a huge amount to buy this software. Apart from the cost of buying, companies have to pay various other costs such as cost of renewal of license, cost of maintenance of software, and many other. Apart from heavy costs, if a bug is found in the software or the organization wishes to add a new feature to the software, then the organization will have to wait for the vendor organization to update the software and make the changes accordingly. But, in open-source technologies, the source code of the software is public, i.e., it is available for everyone. Anyone from any part of world can contribute a new feature or a solution to any preexisting problem and can make modifications. That is why many organizations are switching to open-source technologies from paid licensed software. The "e-Commerce Web App" uses the full-stack technologies that is React.js for the front end, and Node.js and Express.js to manage the middleware. The database used to store the records of user is MongoDB. The web app is developed using various libraries of React.js and Node.js that makes the web app more user friendly. Furthermore, a React.js library known as Stripe.js is used to manage the payment gateway, i.e., to handle the checkout form and hold the credit card details.

2.2 Literature Review

To develop a user-friendly website with database management in order to provide according to Aravindhan et al. [1] services, make the work easier with cost-effectiveness, and trust the user according to Shetty et al. [2]. In system development, usage of database is very common. A database system, according to Paradaens et al. [3], is a collection of programs that run on a computer and assist the user in collecting, changing, protecting, and managing information. The popularity of relational databases has increased tremendously over past 30 years. The usage of relational databases for systems database of organizations is found to be very common these days. Some of the Relational Database Management Systems (RDBMS) are MySQL, Oracle, and PostgreSQL. Each RDBMS is well known and has its own set of advantages. SQL databases were created in order to save information which was structured in manner. Such databases were also known as relational databases. The design of the database is represented by the schema, to which the data should adhere. The data is saved in a structured tabular form, i.e., in the form of rows and columns.

The information stored in these databases can be retrieved with the help of queries written in Structured Query Language (SQL), when the boom in the Internet and Web 2.0 according to Gandhi et al. [4] started to collect a huge amount of unstructured data of users. So, the only commercial solution for data storage that was available at that time was SQL relational databases. The unstructured data of users retrieved from Web was unstructured in manner, and hence, it was quite challenging to store this data in a table-like format. So, a new type of database was required that can store the unstructured data easily. This gave rise to NoSQL databases. MongoDB is a NoSQL database. Using MongoDB, it is easy to store unstructured data as it stores the data if the form of documents which are in JSON (JavaScript Object Notation) format. These new databases needed to support unstructured data that was not suitable for schemas, such as key-value stores, documents, text, graphs, and wide columns. MongoDB is generally referred to as a non-relational database because one cannot establish a connection between the unstructured data of the collections in MongoDB. MongoDB is based on the principles of CAP Theorem. CAP Theorem focuses on Partition, Consistency, and Availability [5]. It uses MERN; thus, the processing and loading of the site is quick.

2.3 Technologies Used

2.3.1 Node.js

Node.js is a JavaScript operating environment written in C++. Node.js is a runtime environment for JavaScript. For high performance, Node.js employs the Google Chrome V8 engine and offers a plethora of system-level APIs such as file operations, web programming, and so on. The JavaScript code on the browser side is subject to various security restrictions at run time, and the client system's operation is restricted. Node.js is designed for network services and uses event-driven, asynchronous programming. The core of Node.js design ideas is event-driven, and it provides the vast majority of APIs in an event-based, asynchronous style. Consider the Net module, where the net Socket object has the following events: connect, data, end, timeout, drain, error, close, and so on. The Node.js developer must register the corresponding callback function based on the business logic. These callback functions are executed asynchronously, which means that, while they appear to be registered sequentially in the code structure, they do not rely on the order in which they appear and instead wait for the corresponding event to fire. The primary benefit of event-driven and asynchronous programming is that they make full use of system resources. The code can be implemented without waiting for a specific operation to complete, and the limited resources can be used for other tasks. This design is ideal for back-end network service programming, which is Node.js's goal. Concurrency request processing is a major issue in server development, and blocking functions can result in resource waste and time delays. Developers can improve resource utilization

and performance by using event registration and asynchronous functions. Many of the functions, including file operations, are executed asynchronously, which differs from traditional languages, as evidenced by the supported module provided by Node.js. Node.js' network modules are particularly large in order to facilitate server development. Developers can build a web server on this foundation using HTTP, DNS, NET, UDP, HTTPS, TLS, and other protocols.

2.3.2 React.js

In the world of web development, React.js is the most extensively used front-end JavaScript library. React.js, and simply React are all different ways to refer to React.js. To develop user interfaces for single-page applications, React.js is used as it is an open-source JavaScript library. React.js promotes reusability by enabling the developer to create components which can be reused in different parts of code. In order to develop large web applications that can change data without refreshing the web page, React.js is used. The reason of popularity of React.js is that it is fast, simple, and scalable. In React, the component renderer receives a set of immutable values as properties in its HTML tags. The component itself cannot introduce any kind of change in properties; instead, it can pass a call back function to do so. An in-memory data structure is built by react whose job is to compute any kind of change and then update that change on browser. The react library only displays the components that actually change. React.js is simply easier to grasp right away. It is very easy to learn react.js and build web applications as it follows a component-based approach. Moreover, due to well-defined lifecycle of React.js and use of only plain JavaScript, developers find React.js easy to learn and develop web applications. React employs a unique syntax known as JSX, which allows you to mix HTML and JavaScript. This is not required; developers can still write in plain JavaScript, but JSX is far more user friendly. To learn react, you just need basic knowledge of CSS and HTML. And because React.js promotes reusability, it supports a lot of code reusability. As a result, we can create iOS, Android, and web applications all at once. React employs one-way data binding, and Flux, an application architecture, controls the flow of data to components via a single control point—the dispatcher. It is easy to debug self-contained components rather to debug the entire React.js web application. React.js applications are extremely simple to test. React views can be thought of as functions of the state, which means we can play with the state we pass to the React.js view and examine the output and triggered actions, events, functions, and so on.

2.3.3 Express.js

Express.js is a web framework for Node.js. It is a fast, robust, and asynchronous in nature. Express.js is a back-end web application framework which is suitable for