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Genetic Algorithm Adaptation To Optimize Smartphone Recommendation System (Srcs)

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Abstract:* This paper describes a preliminary study on adapting the genetic algorithm (GA) in recommending smartphones based on the user's preferences and budget. Different smartphones that came with different specifications have caused broader choices for the user. Amid thousands of smartphone advertisements from numerous brands, buyers have a hard time deciding which smartphone matches their desire. Hence, this research aimed to design and develop a progressive web application (PWA) recommendation system to purchase a smartphone using the Genetic Algorithm (GA). PWA allowed users to choose any platform to input the smartphone specification preferences and budget. With the inputs, it processed through GA and resulting in a list of optimum suggestions. The system features are proven functioning well and managed to receive good system usability of 87.2%.

Keywords: Genetic algorithm, Progressive web application, Smartphone recommendation

1. INTRODUCTION

In this modern era, smartphones have the power to drastically alter how humans communicate, consume information consumption, and use their time. Smartphones used to make calls and read or send emails, view and upload images and videos, play games, and listen to music. Besides, it reacts as a personal diary to record reminders or schedules and contacts, browses the Internet, speech searching, verify the latest news update, current or predicted climate, and text chatting applications such as Facebook, Twitter, and Whatsapp and connect on social networks [1]. Cha [2] claimed an average of 54 per cent estimated that 21 developing and emerging countries such as Malaysia, Brazil, and China had at least one Internet or smartphones by 2015. The ubiquity of smartphone use nowadays is undeniable exponentially growing. Smartphones did not only replace cell phones but a host of other gadgets, to a certain degree, replaced personal computers [3]. Through new features, smartphones are constantly evolving, becoming cheaper and faster each year at the same time. Therefore, it is essential to consider the quality and quantitative requirements so that customers are interested in selecting the most preferred smartphones. For example, pixel density, the camera resolution, RAM, battery power, stand-by time, memory built-in, weight, thickening, scaling, type of the processor, processor, and costs are quantitative parameters. In the meantime, consistency requirements include longevity, reliability, aesthetics, and branding. This results in customers' purchasing decisions different from others because their perceptions and desires vary [4]. Customers would feel satisfied with the criteria leading to an informed decision to make one-hand purchases and meet their expectations [5].

RELATED WORKS

This section describes the smartphone preferences, recommendation technique, and progressive web application on the related issue.

A. Smartphone Preferences

A smartphone is a miniaturized computer that integrates multiple digital device agglomerations and the operating system efficiently, serving thousands of mobile computing applications [8]. With the opportunities provided by the Internet eventually makes smartphones often provide qualitatively different service. Smartphone has become a part of human life basic needs nowadays. The smartphone's advent has significantly changed how we access information, allocate time, and interact with others [9].

There are different product attributes that may be relevant to the consumers' decision-making process. Price is the most obvious concerning the attribute of smartphones [10]. Due to that, a smartphone's price plays a vital role in a company's market strategy. Customers will also compare their needs and want between various products to buy their products inside their budget fit [11]. Therefore, the product quality must match the price so that the customer found that it is worth to invest for a smartphone.

Next, the need for multi-function cell phones for consumers drives the development of smartphones and their operating systems [12]. There are plenty of platforms for development, but the two famous and excellent platforms are iPhone Operating System (iOS) from Apple and Android from Google. Up until now, Android and iOS remain to dominate the market share of smartphones worldwide. Despite that, the Android operating system is considerably newer than iOS. Android takes advantage of iOS weaknesses and promotes a tangible cross-platform development operating system [13].

Furthermore, organizations will always find ways to be different from others, especially in the smartphone industry, which is continuously changing technology. The brand name can be an organization's brand and exclusivity. The brand name can be a title, word, logo, and design to differentiate between the company from the rivals. Acer, Amazon, Apple, BlackBerry, Huawei, Lenovo, Microsoft, Nokia, One Plus, Oppo, Samsung, Sony, and ZTE are some branded smartphones, and each holds different qualities. Marketers were trying to create brand equity to improve customer response to win consumer preference and loyalty. Brand equity is the added value of products and services and may represent how the brand thinks, feels, and behaves with the customer [14].

Smartphones will only become more and more popular. Most people depend on their mobile devices to run their lives nowadays. Thus, the smartphone's brands need to understand the current use and future adoption thoroughly. The brand presence is essential, as it ensures that the business has a specific role in the markets and has established its reputation in the consumer's view [15]. However, the brand of choice depends on the consumer's different variables, calculated by utility [16]. This proposed project focuses on the top five smartphone model brands in Malaysia: Samsung, Vivo, Oppo, Huawei, and Xiaomi.

Besides, there are many high technology smartphones features available in the market today. Therefore, different individuals can choose a specific smartphone to meet their needs and desires—the smartphone features, including software and hardware. Hardware is a system concept that can be physically touched; meanwhile, software, for instance, computer programs, procedures, and documentation are the general terms. Hardware is the smartphone's body, size, weight, colour, and design, whereas software includes computer programs, procedures, and documentation. Many consumer choices can be rational, such as communication, time management, and emotional, such as games, music, camera, and application features [17].

The main requirements for buying smartphones are cost, reliability, battery's lifespan, special promotions, resolution of the camera, size, storage offered, and networking or connectivity options that affect customers' features when purchasing any smartphone [18]. People believed that the smartphone's size is connected to the screen's resolution and inversely linked. For example, the bigger the phone, the higher the resolution, and the harder to carry [18]. Therefore, with the enormous open doors within a short period in the smartphone showcase, smartphone suppliers need to understand factors that satisfy the customer decisions on which model to buy [19]. All of these demands in preferences will be input. Then, the system processed the algorithm and produced a list of smartphones that matches the most such as the price, brand, colour, material, size, year released, screen, front camera, rear camera, weight, chipset, graphic processing unit (GPU), random access memory (RAM), storage, battery type, and battery capacity.

B. Recommendation Technique

Techniques of artificial intelligence (AI) have played a larger role in numerous areas [20]. For instance, recommender systems provide consumers with recommendations for selecting different items from a massive pool of items [21]. Consequently, it leads to creating a program that can allow people to select requirements and remove the dilemma.

Numerous options allow a human being to be uncertain about what is best for them or fulfil their needs. The recommendation helps users reduce the time and difficulty of searching for the information required. The recommendation methods promote users towards the product by collecting and evaluating feedback from other users, implying reviews from specific establishments, and even the user itself [22]. Consequently, many new researchers have embarked on this study to develop more recommendation research and techniques. Several techniques have been evaluated based on the accuracy, ability to receive multiple inputs, and simplicity—for instance, fuzzy logic, content-based filtering, and genetic algorithm. Table 1 explains the details of the comparison.

In conclusion, we choose GA because simple programmability and efficiency feature offered. GAs is a robust optimization system that is widely applicable since it requires users to give many inputs to run in a single run [23]. The GAs maintained the population of an individual's chromosomes along with their fitness scores. It gave more opportunities for individuals with better fitness scores to reproduce than others. Thus, GA able to give the best optimization solution to the smartphone buyer. No matter what the user may input into the system, GA will always provide one recommendation instead of null.

Table 1: Features Comparison Between Recommendation Techniques

Specification	**Content-Based Filtering**	**Fuzzy Logic**	**Genetic Algorithm**
Accuracy	Medium	Low	High
Receive many inputs and run in a	Yes	No	Yes

single run			
Simplicity	No	No	Yes

C. Progressive Web Application

Progressive Web Application (PWA) is also a cross-platform with a new approach that modern web capabilities for providing user experience. PWA uses the most recent technology to incorporate the best of web and mobile apps. PWA hence unifies browsing web experience on mobile and other devices of various pixel sizes, including laptops, tablets, and other devices [24]. The web-based framework is designed using HTML, CSS, and JavaScript standards, and can work on any platform that uses a standards-compliant browser. Besides, the PWA development and evolution is not something that is a new framework or technology. PWAs enable cross-platform development outside of just the mobile sphere [25]. With the advantage of a mobile app's features, PWA enhances user retention and execution without complicating a mobile application's maintenance. The service worker sits at the heart of a PWA. Without a service worker, support will cause PWA does not work correctly [26]. A service worker helps to give the consumers of a web application an offline experience. A service worker is a client-side script that operates on a different JavaScript thread and is independent of the web application. It helps developers programmatically store and preload data so that the code can be loaded from the user cache if the network connection fails.

Furthermore, PWA requires a manifest file. The Web application Manifest File is a JSON file that makes an application from the browser to the user-installable home screen. A manifest file configures the application includes name, short name, icons, background colour, view, width, and theme colour. In short, the manifest used to change PWA behaviour and design.

PWA is chosen as a platform to develop this recommendation system as it is understandable, more reliable, and faster to access. Besides, PWA is a regular application on a computer, and the ability to run it from a uniform resource locator (URL) makes it easy for any user with a browser to use the program [27]. Therefore, it is unnecessary to maintain an application programming interface (API) with backward compatibility. Each user uses the same website version of the code, unlike the version fragmentation of native apps, making it easier to deploy and manage the software. Meanwhile, in order to facilitate usability, effective delivery, efficient administration, and cross-platform versatility, web-based information systems offer easy and cost-efficient resources.

2. RESEARCH METHOD

Three subsections describe the adaptation of GA methodology: system use case, system flowchart, and the phases of GA implementation.

A. System Use Case

Figure 1 demonstrates the overall use case diagram illustrated using the UML on the system users' interaction. There are ten use case identified for this system which seven use cases handled by admin and three cases by the user.

B. Flow Chart

A visual representation of the series of steps and decisions or called a flowchart requires a system using different kinds of symbols containing information. It is essential in design phases to avoid any obstacle and clearly describes the system. The flow of the recommendation process for SRcS shows in Figure 2.

The user must provide 16 specifications of their preferences into the system, including the budget. The chosen specification will then go through the five GA process to get the smartphone's result with the highest matches with the user's input. Lastly, resulting in the top three smartphone recommendation lists.

C. Genetic Algorithm Implementation

As mentioned, GA involved five processes that start with initializing population, followed by fitness calculation, crossover, mutation, and convergence. All user information store in the system as the input. We explained in detail each process involvement and how GA produces the final result. Figure 3 shows the basic process of GA which consists of six main steps started with initialize population, evaluate fitness, creating a new population through the selection of the individuals, process the crossover and mutation, test the condition and if satisfied, return the best individual of the current population. Else, repeat the process.

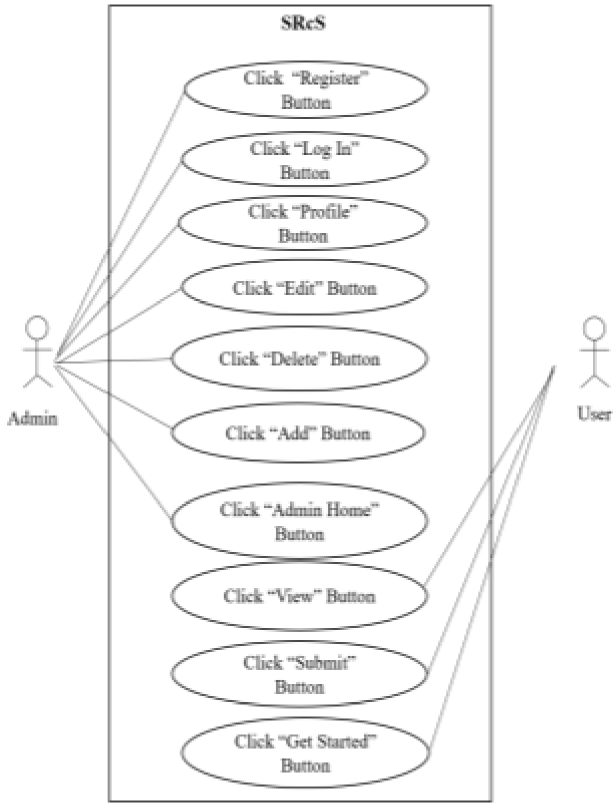

Figure 1: Overall SRcS Use Case Diagram

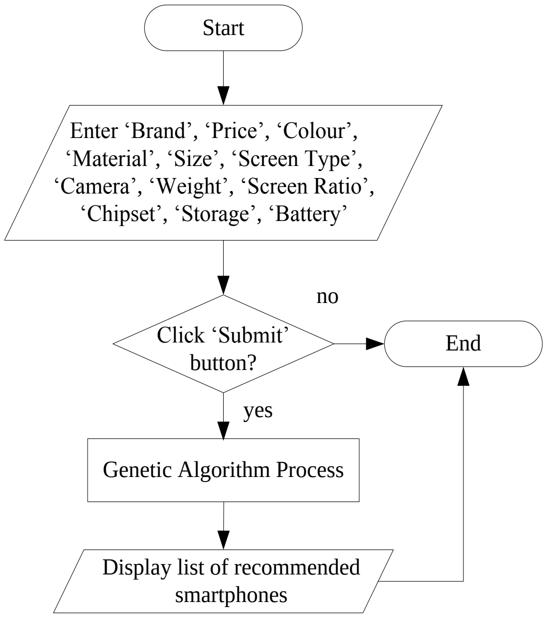

Figure 2: Process for SRcS

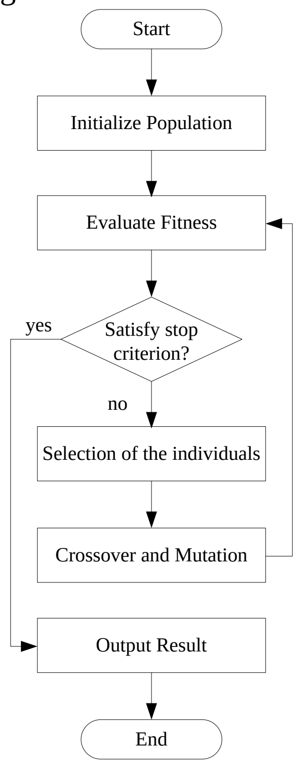

Figure 3: Genetic Algorithm Process

1) Initialize Population:

GA begins with an initial population of typically randomly formed phenotypes. The GA needs to continue to evolve new genotypes from the population and evaluate each genotype's fitness at each iteration. The population will create chromosomes up to 150 generations as their stopping condition defined in for loop. Each chromosome encodes with three types of smartphones. Each smartphone contains information like the brand, price, colour, material, size, year release, display, camera, weight, chipset, CPU, GPU, RAM, memory, and battery, as in Figure 4.

Smartphone23	Smartphone67	Smartphone09	Fitness
Brand	Brand	Brand	
Price	Price	Price	
Color	Color	Color	
Material	Material	Material	
Size	Size	Size	
Release Year	Release Year	Release Year	
Screen Type	Screen Type	Screen Type	
Camera Number	Camera Number	Camera Number	
Rear Camera	Rear Camera	Rear Camera	
Front Camera	Front Camera	Front Camera	
Weight	Weight	Weight	
Resolution	Resolution	Resolution	
Chipset	Chipset	Chipset	
GPU	GPU	GPU	
RAM	RAM	RAM	
Storage	Storage	Storage	
Battery Capacity	Battery Capacity	Battery Capacity	
Battery Type	Battery Type	Battery Type	

Figure 4: Chromosome Encoding

2) Evaluate Fitness:

The next phase is calculating each chromosome's fitness by comparing the user with database chromosomes. Each smartphone holds an equal percentage of totalling 100%. The fitness function considered as the inverse of the input given, for example, we have three variables: a, b, and c. Fitness means the best result for the input given for a, b and c, so we assume the value will be d as in Eq (1).

$$a + b + c = d \qquad \text{Eq (1)}$$

The process of fitness function can be declared as the inverse of | a + b + c – d | because we need to reduce the sum of the three variable from deviating from d. Thus, we identify the fitness function as in Eq (2).

$$\textit{Fitness Function} = 1/\,|\,a + b + c - d\,| \qquad \text{Eq (2)}$$

3) Crossover and Mutation:

Once we have calculated the fitness value, the best fitness value is chosen and arranged to descend from the highest fitness-to-lowest. The first three chromosomes' highest fitness value will undergo the crossover and mutation operation, and we sorted out again the fitness value. The crossover example between chromosome X and Y shows in Figure 5. The GA process chooses and displays the highest fitness value data to the user.

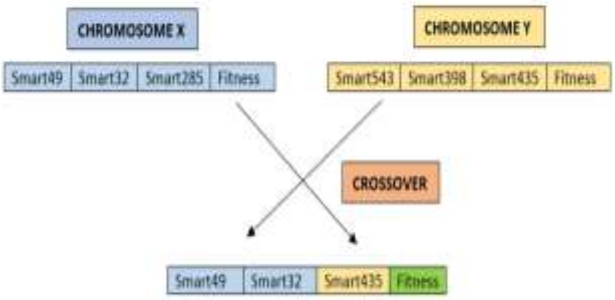

Figure 5: Example of Crossover Process

D. Progressive Web Application Implementation

A PWA requires a web manifest and service worker file. In manifest file allows the system to execute the full-screen web app as a standalone application, assign an icon to show when the application finished, and assign a theme and background colour app on the computer. Furthermore, this app also has implemented an installation banner that makes it easier to be download on any device.

Next, service workers are the mastermind of PWA. The service worker intercepts each request as middleware. If the request is cached, instantly, it responds or otherwise recovers it from the channel. [28]. There are two caches implemented in this system, which are dynamic and static. In static stores, every single asset while in dynamic fetches all previously requested assets while users online limit to 20 requests to be stored.

Inside service worker also implements install and activate event code. An event code fires when the service worker is mounted and occurs once. If the service worker is installed and activated, the device will use the currently installed service worker. The caches are delete whenever there are changes to cache the latest version of code. Therefore, every declared asset will be cached automatically.

3. RESULT AND DISCUSSION

This segment addresses SRcS results and conclusions. In this study, two types of tests were performed, which are testing on functionality and usability.

A. Functionality Testing

Functionality evaluation is testing to verify the outcome for each use case module. We are evaluating every module, whether it could generate the predicted result. Figure 6 and Figure 7 indicate the SRcS snapshot, the interface where the user fill-up the form with the questions began with the brand, price, and the specification preferences question. Then, SRcS shows the user's smartphone recommendation result, as in Figure 8.

Figure 6: Snapshot of SRcS Submenu1

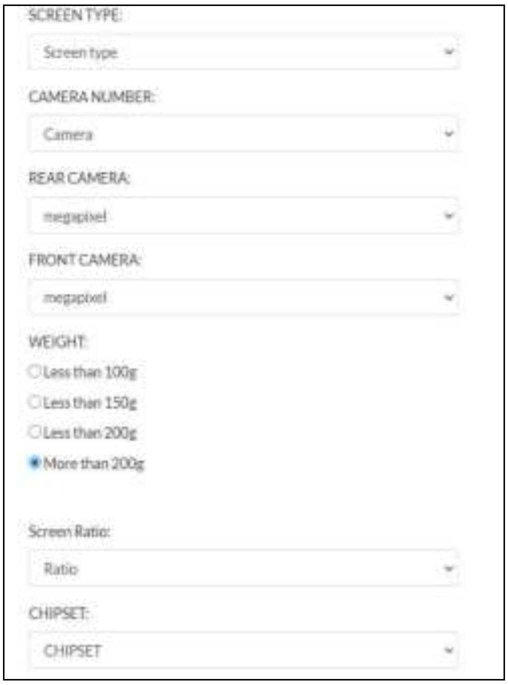

Figure 6: Snapshot of SRcS Submenu2

Figure 8: SrcS Recommendation Result

We performed the functionality test according to the use case of SRcS, and Table 2 displays the SRcS outcome on the functionality test to ensure that it works according to the proposed.

Table 2: SRcS Functionality Test Result

Use Case	**Description**	**Remark**
Register Button	Allows a new admin to register into the system	Passed
Log In Button	Allows admin to log in into the profile page	Passed
Profile	Allows admin to view their	Passed

Button	account information	
Edit Button	Allows admin to update their account information	Passed
Delete Button	Allows admin to delete smartphone details system	Passed
Home Button	Allows both user and admin to view all smartphone available in the database	Passed
Find Button	Allows both users to find a smartphone that matches with user's preferences	Passed

B. *Usability Testing*

Usability testing is about bringing actual people to connect with the system and watch their behaviour and reactions. The key benefit and aim of usability testing are to detect usability problems with a design as early as possible before the design is adopted. This step ensures that the program built is convenient for someone with no computer science experience to use. Therefore, the usability assessments used the System Usability Scale (SUS), an analysis consisting of a ten-item scale survey.

The SUS is a standard tool for calculating a broad product range and systems [30]. The respondents are given the items' statement and reflect the 5-point scale agreement or disagreement with the statement. We asked 30 SUS respondents to get in hand with the fully developed system and immediately answer ten-item from the SUS. They need to fill in all items, participate in thoughts and concepts, give feedback, and share emotional experiences. We summarize the SUS results for each of the questions towards 30 respondents. The form of multiple bars depicted in Figure 9.

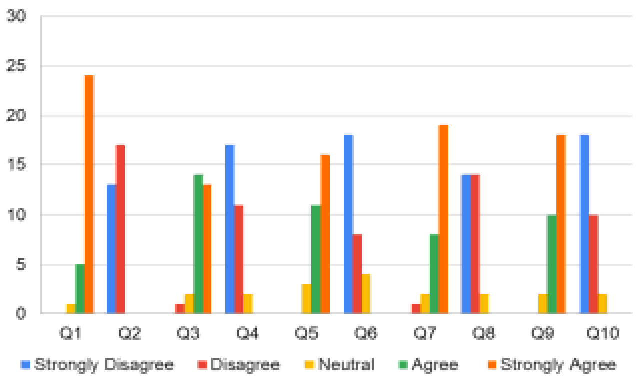

Figure 9: SUS Questionnaire Result for SRcS

The score for system usability results determined by the input range from 1 to 5, and it based on each item's contributions. The score for odd-numbered questions will minus 1 score. Meanwhile, for even-numbered questions, the score will be subtracted with 5. Then, we total up the scores from every question and times with 2.5 to find the final score. Alathas [29] has highlighted that if the SUS average score is 68%, it indicates the system has good usability since it reaches or exceeds 68%.
As illustrated in Figure 10, a histogram summarizes the total SUS values gained from the developed SRcS. The range started at 60% and followed by a new range for every 5%. Each

range frequency indicates in the vertical axis. Based on the histogram, the highest frequency is 95% to 100%, in which 3 respondents fall into that range. There is 1 respondent who scored within the lower range, which is 60% to 65% and 65% to 70%, respectively. The SRcS average SUS score is 87.17% resulting in SRcS have good usability.

Figure 10: SRcS Histogram for Total SUS Scores

4. CONCLUSION

In this research, the main aim was to develop an innovative PWA system that provides smartphone recommendations. Using GA technique advantages, SRcS helps users seek out and purchase a smartphone according to specification interests, needs, and allocated budget. Tacitly, it helps to ease the time-consuming manual survey via websites. We carried out the functionality testing by assessing and testing the use case function, and the SRcS is proven to work functions correctly. The usability testing shows a good result with an average SUS of 87.17%, exceeded the standard 68%. For the next improvement, SRcS able to view the picture of the smartphone, and this system requires a high and powerful specifications device to get results more accurate.

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