



# Comparative Study of Search Engine Optimization Algorithms On Retrieval Time and Precise Data Entry for Websites

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**Abstract:** A search engine is a complex software in that a finder visits numerous websites and their pages to find essential data. It is the primary source to find content on the World Wide Web. Search Engine Optimization (SEO) methods have been invented to make user searching smoother. Although search engines are intelligent, sometimes they also provide irrelevant data. As a result, researchers have found a solution to this problem by implementing SEO techniques. SEO techniques make websites more visible and produce organic search results. Thus, this study proposed the implementation of Artificial Neural Networks (ANN) and Particle Swarm Optimization (PSO) for SEO problems on online shopping websites and educational websites. These algorithms are evaluated based on retrieval time and precise data entry by using precision and recall. Moreover, PageSpeed Insights is used to check the speed index of the websites. The research outcome found that PSO outperformed ANN for both shopping and educational websites. PSO has a minimal retrieval time, which is 0.04 seconds for an online shopping website and 0.10 seconds for an educational website. As for precision and recall, online shopping websites have been proven to have the highest precision score of 0.67 and 0.63 recall score. The simulation analysis results show that future researchers should concentrate more on determining the significance of each SEO approach and the best blend for various sectors.

**Keywords:** Search Engine Optimization, Artificial Neural Network, Particle Swarm Optimization, retrieval time

## 1. Introduction

In this modern era, the usage of the internet is growing rapidly day by day. Each day the number of users that connect to the internet, which is known as the global wide area network increases due to the rising of the World Wide Web. This World Wide Web somehow interlinks with the word optimization. This is because when users came across numerous numbers of web pages based on their search, they could not obtain the exact web page which they needed as well as the time taken for the web page to display is unpredictable. This is where the operation optimization must take place. Optimization can be defined as a process for finding the most effective way to obtain viable performance based on the user's search through the Search Engine.

A search engine is a complex software that a finder visits to numerous websites and their pages to find important data [1]. A search engine is a main source to find content on the World Wide Web. Basically, it can be defined as a software tool used to search for any sort of paper or information using a certain keyword, then it returns the searched list of details based on the key words [2]. There are several search engines available on the internet such as Google, Yahoo, and Bing that help to display the output of both relevant and irrelevant data [3]. Although search engines are smart, sometimes they also provide irrelevant data. As a result, researchers have found a solution to this problem by

implementing the search engine optimization (SEO) techniques. SEO plays an important role to produce organic search results [4]. SEO is a series of modifications and strategies that make it simpler for search engines to crawl, index, and interpret the website's content [5]. It is also known as the method of enhancing the feature and amount of website traffic to a website or a web page from search tools. Other than that, SEO helps to increase a website's popularity at the top of a search engine's search results [6]. It helps Search Engine to make noticeable the content of the web page [7].

The aim of the research was to implement a search engine optimization algorithm for obtaining the best retrieval time and precise data entry for websites. The first objective is to implement Artificial Neural Network (ANN) and Particle Swarm Optimization (PSO) for education and online shopping websites. The second objective is to evaluate the algorithms implemented in the first objective in terms of retrieval time and precise data entry. This study uses two case studies which are online shopping and educational websites. The research was carried out using ANN and PSO. Two parameters were used for performance evaluation, namely the retrieval time and precise data entry. The datasets were obtained from Kaggle, and PageSpeed Insights was used to carry out the research experiment.

## 2. Related Work

Search Engine Optimization is the act of enhancing the possibility of a site appearing at first page of a search result [8]. The optimization procedure was often developed to demonstrate the search results produced by search engine operators [9]. The example of search engines that are frequently used are Google, Yahoo, Bing, Overture, Baidu, and DuckDuckGo. SEO is well recognized for optimizing webpages to make those search engines friendly for users [10]. Getting started with SEO practices can help improve the quality of your website. It can be said that SEO methods help internet users to obtain valuable data easily in just one click of search. On-page Optimization illustrates to the settings that are applied to a website that are optimized for search engines [2]. Table 1 shows the implementation of various algorithms in SEO used by different authors.

**Table 1 - Table of implementation of various algorithms in SEO**

Authors	Technique	Summary
[2]	Genetic Algorithm, Particle Swarm Optimization, Distance Rank Algorithm, Ranking and Suggestive Algorithm	Compared various search engine optimization page ranking methods which are currently in use and implemented different algorithms for offline page ranking and online page ranking. The results show that only Particle Swarm Optimization, Weighted PageRank is less effective compared to other page ranking algorithms, but it has good performance in different approaches as well as suitable for other applications.
[17]	On-Page Optimization and Off-Page Optimization	Proposed updated site audit checklist and rules for each level of the SEO framework. In this research, to obtain higher page rank result off-site widely used as it uses link building elements to optimize and get higher page rank level.
[18]	Page Rank and HITS Algorithm	A new page ranking method called "Aggregate PageRank" (APR) is suggested, which computes the rank by considering both the links and the contents of the web page. The outcome produces show that APR provides more accurate findings when assessing the significance score of web sites compare to HITS algorithm.
[19]	On-Page Optimization and Off-Page Optimization	Identified and analyzed Google analytics data to determine the needs for On-Page SEO implementation. The results shows that both On-page and Off-Page is dependent on each other's function to improve the online visibility of the web pages.
[20]	Multilayer Perceptron Neural Network and Artificial Neural Network	Designing a crawler and parser, as well as learning the dataset with ANN, to analyze the key parameters of websites that determine page rank. The outcome shows that both neural network techniques collaborate to produce a high accuracy in predicting rank of site based on keywords and it has a very good performance.
[5]	On-page and Off-page Optimization	The effectiveness of SEO on the ranking of web pages in results page, as well as its impact on increased traffic to the website, is being investigated. The outcome of this research shows On-page optimization is better than Off-page optimization in producing interesting content of website.
[21]	Page Rank Algorithm	Analyzed the possible advantages of SEO by examining and concentrating on the drivers of organic clicks on a dataset without taking cost into account. The result shows that page ranking plays an extremely vital role in retail sites as it improves retailer's branding equality.

Search engine optimization is divided into two groups which are On-Page Optimization and Off-Page Optimization. On-page Optimization illustrates to the settings that are applied to a website that are optimized for search engines [2]. The elements contained on On-Page SEO are SILOS, site performance, title tags for links, canonical URLs, anchor text, site map, 301/404 errors, robots.txt, keyword density and meta-tags. Off-Page Optimization aims at enhancing the authority of the domain by creating content and obtaining backlinks from other websites. Link building is a term used to describe off-page SEO. The elements that are contained in off-page SEO are RSS feeds, directory submission, social bookmarking, article marketing, social media, press releases, forum/blog commenting and forum posting. The tools that help to enhance the SEO of a website are exist in current market are Google Analytics, Google PageSpeed Tool, Alexa, and Google AdWords Keyword Tool [11].

There are two algorithms that were implemented in this ANN and PSO. An ANN is known as simple neural network that is made up of three layers which are an input layer of neurons, one or two hidden layers of neurons, and a final layer of output neurons [12]. Neural networks are rapidly being utilized to solve issues including prediction, estimation, pattern recognition, and optimization [13]. ANN has proven to be universal approximation and it is used to predict the rank of new websites that perform well on test data. The next algorithm is PSO where it is a stochastic optimization approach that is population-based [14]. PSO is well-known for its ease of implementation and ability to quickly reach an agreement on a generally feasible strategy [15]. The fundamental advantage of these PSO algorithms is that they do not require any encoding decoding operations, but the drawback is that there is premature convergence because of the faster loss of diversity [16]. Consequently, it is obvious that the PSO algorithm is appropriate for SEO implementation since it can give exact data entry depending on the user's search as well as the retrieval time of the result.

### 3. Methodology

#### 3.1 Research Framework

The research framework is divided into four phases. Each phase helps to complete the overall research perfectly. The function of each phase will be explained in this section. Fig. 1 shows the flow of the research.

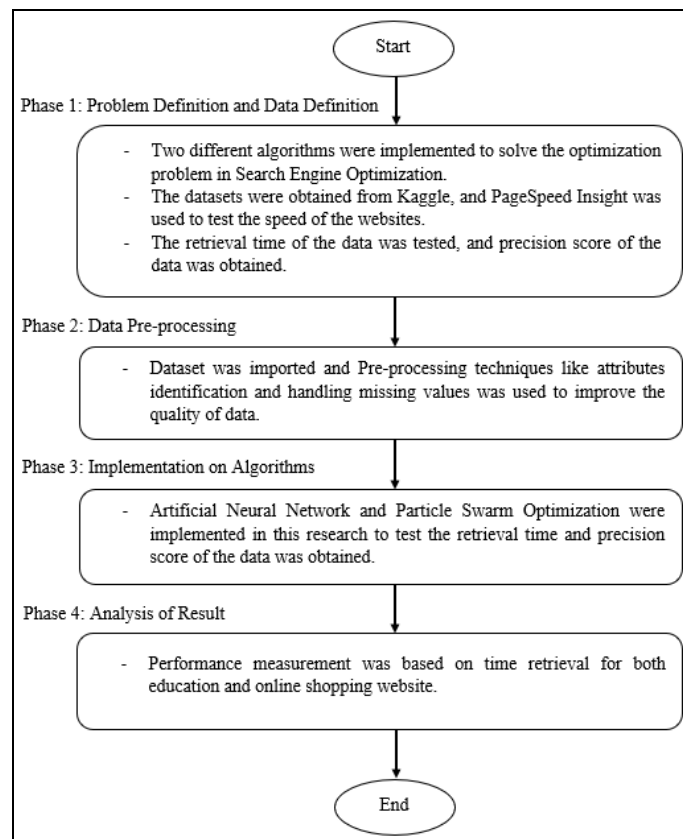


Fig. 1 - The overall flow of research methodology

##### 3.1.1 Phase 1: Problem Definition and Data Definition

The problem identified was that the relevant data was hard to see in a short period of time, while the other problem was about obtaining the correct materials based on the search. Case Study One is known as a shopping website while

Case Study Two was considered as education website. For the education website the experiment was conducted using Coursera website while for shopping website was Sephora.

The dataset of Sephora such as Product Related Duration, Exit Rate, and Product Search Result was chosen to test out. The second case study was the educational website Coursera. The dataset of Coursera that was chosen to carry out this research are Response Time, Sum of Click and Total Result of Search. Fig. 2(a) shows the interface Sephora website while Fig. 2(b) displays the interface of the Coursera website.

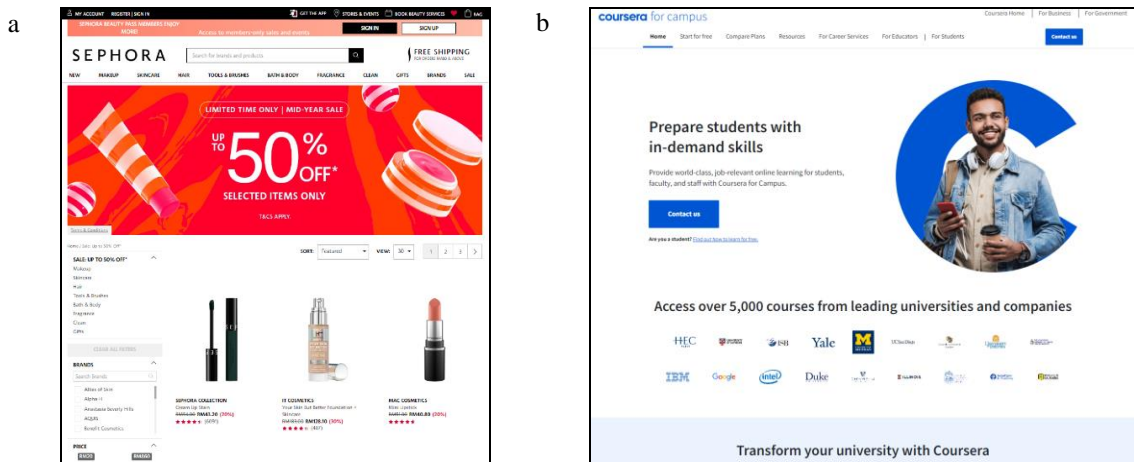


Fig. 2 - (a) Sephora website; (b) coursera website

### 3.1.2 Phase 2: Data Pre-Processing

The second phase of this research is data pre-processing. Microsoft Excel was used for pre-processing and handling structured data as it is an excellent tool. Regression analysis method was used to eliminate data systematically. Data pre-processing consists of data normalization. For this research, min - max normalization was done. This min-max normalization normalizes numeric features such that they remain in the range [0,1].

### 3.1.3 Phase 3: Implementation of Algorithms

ANN and PSO were implemented to test the retrieval time of data and precision score of data entry. This program was implemented using MATLAB R2022a. The main toolbox that was used to develop the code for ANN and PSO is MATLAB's Optimization Toolbox. Inside the toolbox, there was a NN tool that commands to run the neural network program.

Neural networks have recently been regarded as universal function approximators. It was feasible to estimate a function without knowing the type of the function. The mapping of the issue domain, problem knowledge, and solution space into the network's input state space, synaptic weights space, and output space is characterized as the problem-solving process [22].

In 1995, Eberhart and Kennedy introduced the PSO approach. PSO is a meta-heuristic algorithm inspired by animal flocks and fish schools. A swarm is normally referred to as anything in PSO algorithms as the population  $P = p1, pn$ . Particles refer to the potential solutions  $p1, \dots, pn$  [23].

### 3.1.4 Phase 4: Analysis of Result

The last phase 4 is about performance measurement. Retrieval time was one of the ways where the results were analyzed when the algorithms were applied, and the program code were executed. The time is measured using unit seconds. The lowest execution time is the better algorithm.

Precision and recall are two terms that are frequently used in the field of information retrieval. Precision refers to the number of relevant documents recovered, whereas recall refers to the number of relevant documents retrieved [24]. There are some mathematical formulae to calculate this precision and recall:

$$\text{Precision } P = TP / (TP + FP) \tag{1}$$

Where TP indicates the True Positive and FP is False Positive. The formula describes the number of True Positive (correctly retrieved documents) / (Total number of documents retrieved).

$$\text{Recall } R = TP / (TP + FN) \tag{2}$$

Where TP denotes as True Positive, and FN is False Negative. This formula shows the number of True Positive (correctly retrieved documents) / (Total number of relevant documents retrieved).

This precision and recall formula were implemented in MATLAB and the output was generated in score value between 0 to 1. The highest the precision and recall score considered to be the better retrieval of information.

Page speed was used to increase the speed of websites. By keying in the URL of websites and running through Google's PageSpeed Insights it helps to find out the page's load time as well as increase the speed of the site.

## 4. Result and Discussion

The results of both ANN and PSO were compared in terms of the retrieval time as it was for optimization. For performance measurement, precision and recall score results were obtained by executing on same dataset that were used for ANN and PSO. A comparative analysis was done to compare the complexity of two algorithms to identify which algorithm performed better.

### 4.1 Results of ANN Algorithm

The ANN algorithm was implemented on Case Study One and Case Study Two. The results obtained from the implementation on both datasets were discussed here.

#### 4.1.1 Implementation of ANN for Case Study One

To obtain the best retrieval time for this shopping case study, the dataset undergone training and testing. There were 100 datasets consisting of two input variables and one target variable. The input variables are product related duration and exit rate while target variable was total result of product.

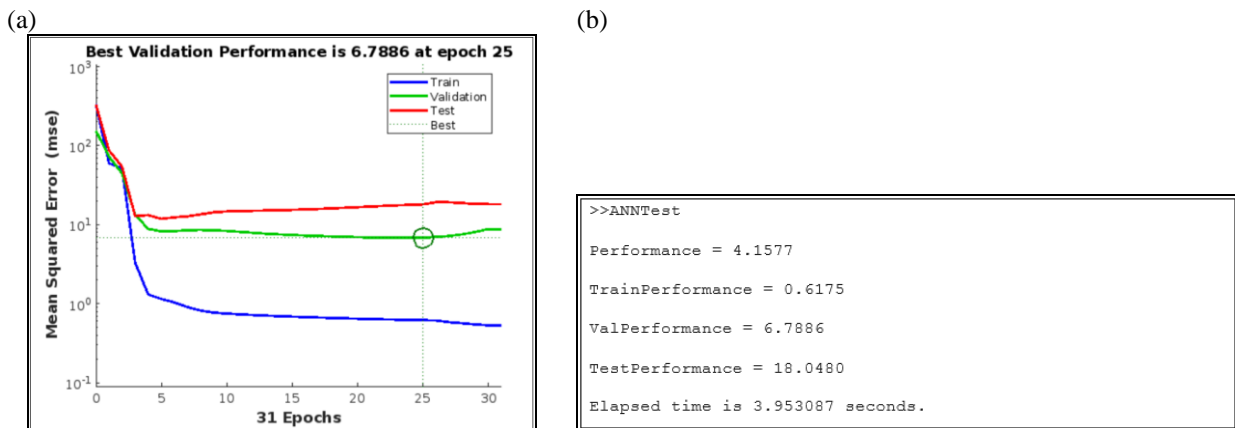
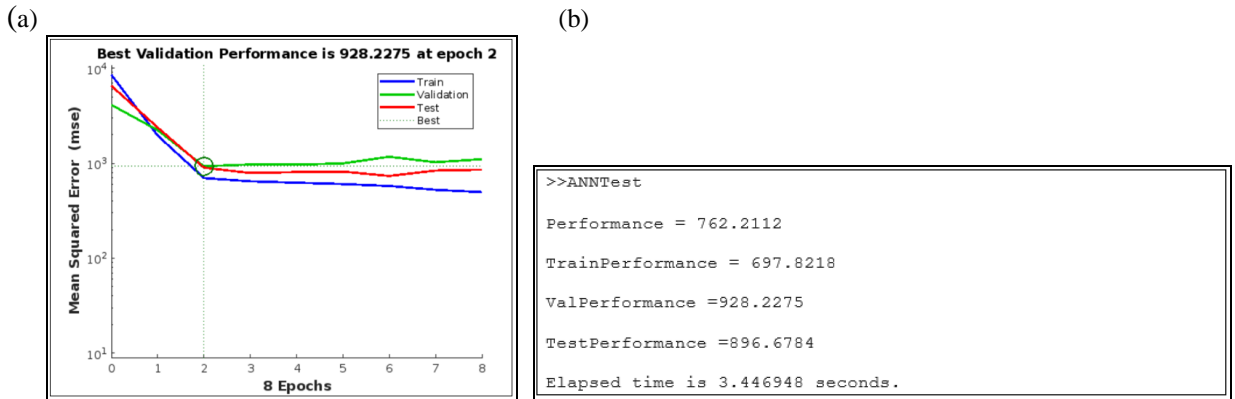


Fig. 3 - (a) Performance graph; (b) output of execution

Fig. 3(a) illustrates the performance graph where the best validation performance was obtained at 6.7886 at epoch 25. Fig. 3(b) represents the overall execution of the training the network where it has the details of performance, train performance, validation performance and test performance. The overall elapsed time taken to run this case study one is 3.95 seconds.

#### 4.1.2 Implementation of ANN for Case Study Two

The case study two was based on educational website. The same process of implementation was taken place to carry out the training and testing. There were 100 datasets used in this case study. This dataset consists of two input variables which were sum of click and total results of search while one target variable was the response time.



**Fig. 4 - (a) Performance graph; (b) output of execution**

Fig. 4(a) illustrates the performance graph where the best validation performance was obtained at 928.2275 at epoch 2. Fig. 4(b) shows the overall execution of the training the network. In this case study, the total elapsed time taken was 3.45 seconds.

### 4.2 Results of PSO Algorithm

The PSO algorithm was executed in Case Study One and Case Study Two. This PSO algorithm was implemented to solve the maximization problem.

#### 4.2.1 Implementation of PSO for Case Study One

This case study one was executed to get the optimum value and best retrieval time. The objective function was defined to solve maximization problem. The objective function was defined to solve maximization problem. Lower boundary and Upper boundary values were set to run the program. Table 2 represents the attributes and boundaries used in this study. The objective function for this case study defined as:

$$y = 1.792 + 0.0477 * x (1) + 0.5513 * x (2) \tag{3}$$

Where y = product search result.

**Table 2 - Attributes and boundaries of case study one**

Symbol	Input Attributes	Boundaries	
		Lower Boundary	Upper Boundary
$x_1$	Product Related Duration	2.67	97
$x_2$	Exit Rate	0.01	0.17

PSO parameters were set, and the program was performed with maximum of 100 iterations. Case study one had gone through the maximization process and achieved its optimum value at iteration 70 as shown in Fig. 5(a). Fig. 5(b) illustrates the optimized solution of the problem.

From Fig. 5(b), it is observed that the best value of the objective function was obtained after 10 independent runs is 6.4908. The simulation total time taken is 0.04 seconds.

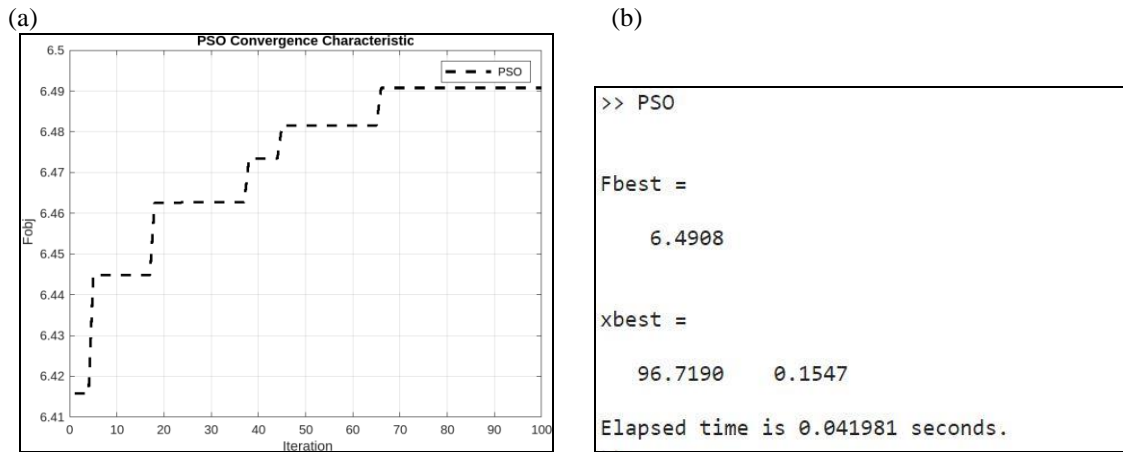


Fig. 5 - (a) PSO convergence characteristics; (b) output of optimized solution

### 4.2.2 Implementation of PSO for Case Study Two

In case study two, the objective function was specified to solve maximization problem. The parameters constrained and boundaries are set to run the program to obtain the best optimum value and elapsed time. Table 3 shows the attributes and boundaries used in this study. The objective function for this case study described as:

$$z = 105.668 + 10.2943 * x(1) + 0.1773 * x(2) \tag{4}$$

Where z = response time in seconds.

Table 3 - Attributes and boundaries of case study two

Symbol	Input Attributes	Boundaries	
		Lower Boundary	Upper Boundary
$x_1$	Sum of Click	1	3
$x_2$	Total Result of Search	8	888

The program was performed with a maximum of 100 iterations. Case study two had gone through the maximization process and achieved its optimum value at iteration 11 as shown in Fig. 6(a). Fig. 6(b) represents the outcome of optimized solution of this problem.

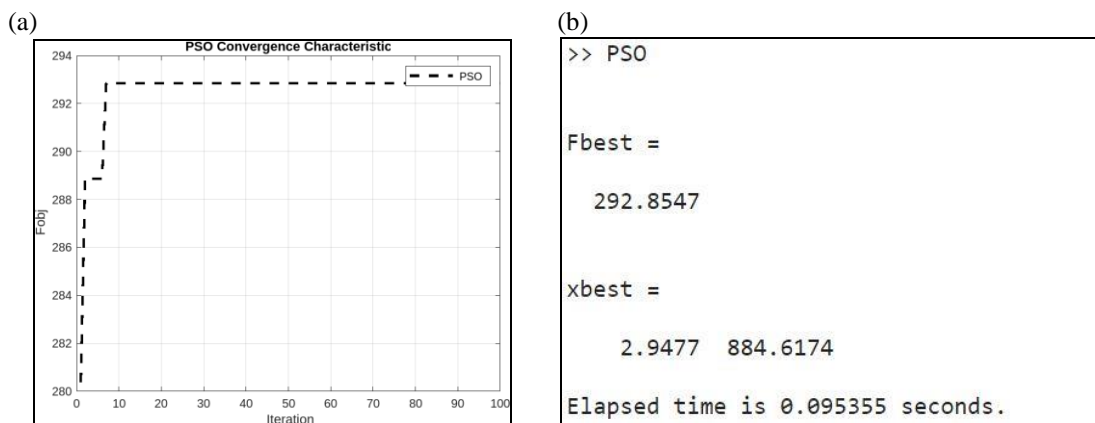


Fig. 6 - (a) PSO convergence characteristics; (b) output of optimized solution

From Fig. 6(b), it is observed that the best value of the objective function was obtained after 10 independent runs is 292.8547. The simulation total time taken is 0.10 seconds.

### 4.3 Comparative Analysis of Performance Measures

The performance measures taken into consideration for this research are retrieval time and precision and recall for data entry. A comparative analysis was done in this segment to determine the better performing algorithm.

#### 4.3.1 Comparison of Retrieval Time

Retrieval time is one of the crucial aspects of that needs to be considerate when searching for a result in websites. Both the websites have generated different retrieval time. A comparison graph was created to display the difference of the retrieval time as shown in Fig. 7.

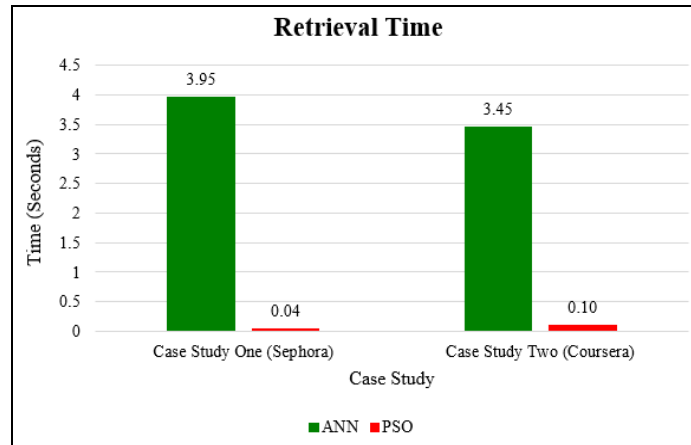


Fig. 7 - Comparison graph for retrieval time

Based on Fig. 7, both case studies indicate that ANN algorithm took a longer time for retrieval. ANN algorithm has the highest retrieval time that is 3.95 seconds for case study one. Meanwhile, PSO algorithm has the minimal retrieval time for both the case study one and case study two. Sephora has the shortest retrieval time which is 0.04 seconds by implementing PSO algorithm. ANN took a lengthier time to generate the outcome as it must have undergone training for the neural network. In overall, PSO outperformed ANN for both the case study one and case study two.

#### 4.3.2 Comparison of Precision and Recall

Precision and Recall are performance metrics that applied to data retrieval. The highest the precision and recall score considered to have better retrieval and precise data entry. A comparison graph was generated based on the precision and recall scores of the case studies.

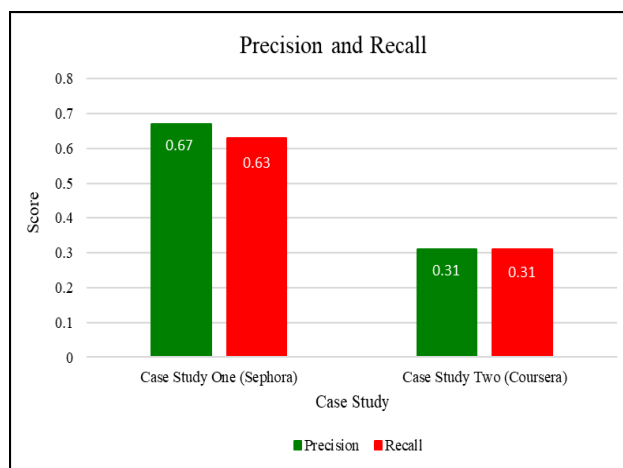


Fig. 8 - Comparison graph for precision and recall

Based on Fig. 8, it can be clearly seen that Case Study One, which is Sephora, has the highest Precision and Recall score compared to Coursera. Sephora has precision score of 0.67 and 0.63 recall score while Coursera has precision and recall score of 0.31. Therefore, Case Study One has proven to have the greatest retrieval and most precise data compared to Case Study Two.



### 4.3.3 Comparison of Page Speed Insights Tool

Page speed was used to boost the speed of the website. Sephora and Coursera websites was analysed using this Google PageSpeed Insights Tool. The speed index of both websites was observed and evaluated. Fig. 9(a) denotes the speed index of Sephora while Fig. 9(b) displays the speed index for Coursera.

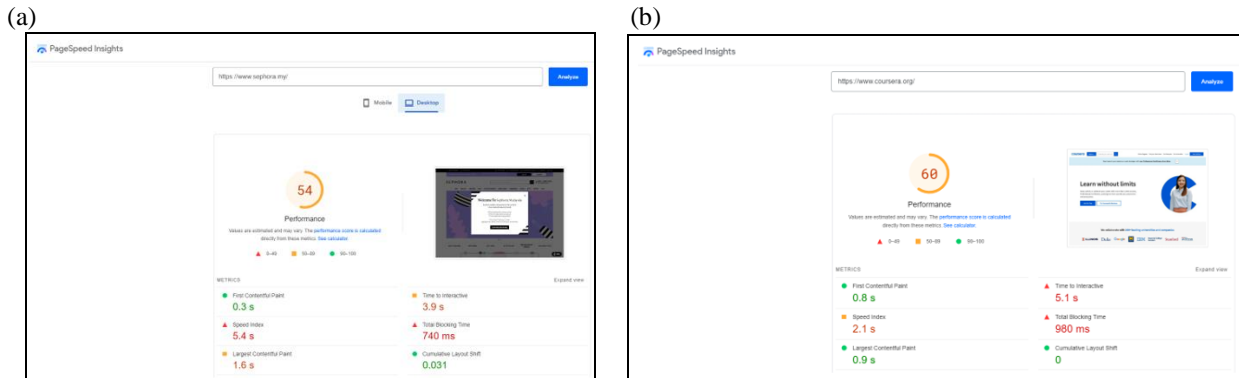


Fig. 9 - (a) Speed index for Sephora; (b) speed index for coursera

Fig. 9(a) and Fig. 9(b) illustrate the speed index of both websites together with its Performance level. Sephora website shows that it has high speed index which is 5.4s compared to Coursera that was only 2.1s. Nevertheless, Coursera has a superior performance level of 60 whereas Sephora has a performance level of 54. This performance level was evaluated on other criteria of the websites.

## 5. Conclusion

This research was conducted with the notion of implementing Search Engine Optimization Algorithms to test the retrieval time and precise data entry for websites. The two algorithms that were used in this study are ANN and PSO. The algorithm was implemented on two different case studies which are online shopping website and educational website. Case Study One was about Sephora while Case Study Two was about Coursera. Based on the result, it is proven that both the algorithms have their own uniqueness and performed well in the given case studies. As for retrieval time PSO has proven to be the better algorithm with the shortest retrieval time. On the other hand, ANN was implemented to solve minimization problems while PSO was used to solve maximization problems. As both are involved in solving different optimization problems, therefore there are some differences in producing a good result. Based on the Google PageSpeed Insights Tool Analysis Sephora website has a greater speed index compared to Coursera. Some improvements can be made in continuing this research. The improvements that can be made in future are trying to implement different algorithms which are Ant Colony Optimization and Spiral Optimization Algorithm. Other than that, future researchers can implement improved or enhanced ANN and PSO to improve their performance for optimization problem. Besides that, can use different programming languages such as R to perform the analysis to learn about how to write code in a different way to obtain output.

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