

Virtual Labs for Linear and Binary Search - Requirements Specification

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1 Introduction

1.1 Purpose of the Document

This is a Requirements Specification document for a *virtual lab* on the topic of "Linear and Binary Search". This document describes the objectives of the lab and all the experiments to be included in the lab. This document is intended to direct the design and implementation of the target lab.

1.2 Lab Summary

Name Linear and Binary Search

Domain Computer Science and Engineering

Objective The objective this lab is to demonstrate the process of searching for an item in a list of items through different methods of searching. After performing the experiments in this lab, the learner is expected to -

- Have a clear understanding of the formulation of search problem.
- Be able to identify the situations where a problem can be modeled and solved as a search problem.
- Understand the basic operations involved in a search algorithm.
- Be able to differentiate between scenarios where Linear and Binary Search is applicable and understand the advantages and limitation of both search strategies.

Scope of the Search Problem As the basic concept of comparison remains the same irrespective of the type items; for the experiments in this lab, the search problem is limited to searching for numbers (Integers).

Size of the list 5 (min) to 10 (max).

- Limiting the size of the list allows us to keep the interface manageable.
- Small lists may not be able to effectively demonstrate the differences between various strategies. (?)

Range of Values Non-negative integers in the range of 0 (min) to 100 (max).

Target Audience Undergraduate students in second or third year of a B. Tech / B. E. degree in Computer Science and Engineering (or similar disciplines).

Number of Experiments 5

2 Interface Requirements

The user interface should have the following elements:

1. **Navigation** Links to all the experiments.
2. **Experiment Details**
 - Objective** Learning objectives of the experiment.
 - Experiment Setup** Description of the experiment interface and how to interact with the various elements.
 - Instructions** Steps-by-step guide for the user to perform the experiment.
3. **Interactive Experiment** The actual setup that presents the users with various interactive elements and allows them to perform the experiment and gives useful feedback at each step.

2.1 Experiment Interface

The experiment interface should provide the following:

2.1.1 Elements

Search Space List of items that acts as the search space.

Search Target Number that the user needs to search for.

Control buttons Buttons that allow the user to perform required operations.

Prompt The system should give a feedback message to the user after each interaction. This feedback indicates the result of the latest action and hints towards the next possible actions.

1. Search Space

The search space for the search problem in our scope is a list of numbers. The search target may or may not be present in the search space. Each item in the list has two elements: First, the number that we compare the target with and second, the index of the item in the list.

3 Experiments

3.1 Random Search with Replacement

3.1.1 Objective

The objective of this experiment is to demonstrate the process of searching for an item in a list by randomly picking one item at a time from the list until the search item is found.

3.1.2 Learning Outcomes

The user should be able to learn the following after performing this experiment:

1. **Comparison as the Fundamental Operation of Search** The user should be able to observe that the basic operation that is required to perform a search, is **comparison** between two items and therefore, the notion of **equality** must be understood.
2. **Random Search is non-terminating** The process of searching for an item by randomly picking items from the list such that one item can be picked multiple times (with replacement), is non-terminating. The process terminates only if the target item is present and is found.

3.2 Random Search without Replacement

3.2.1 Objective

The objective of this experiment is to demonstrate the process of searching for an item in a list by randomly picking one item at a time (without replacement) from the list until the search item is found.

3.2.2 Learning Outcomes

The user should be able to learn the following after performing this experiment:

1. **Random Search without replacement is terminating** The process of searching for an item by randomly picking items from the list such that one item can only be picked once (without replacement), is terminating. The process terminates either if the target item is found, or when there are no items left to compare with.

3.3 Linear Search

3.3.1 Objective

The objective of this experiment is to demonstrate the process of searching for an item in a list by iterating over the items of the list in the order of their position in the list.

3.3.2 Learning Outcomes

The user should be able to learn the following after performing this experiment:

- 1. Linear is terminating** Linear Search terminates when wither the item is found, or one iteration over the list is complete.
- 2. Linear Search is a refinement over random search without replacement** Linear Search simulates "random search without replacement" by switching the strategy of randomly picking items to compare with a more systematic way of picking item in a predefined order.

3.4 Linear Search on Ordered List

3.4.1 Objective

The objective of this experiment is to demonstrate the process of searching for an item in a sorted/ordered list by iterating over the items of the list in the order of their position in the list.

3.4.2 Learning Outcomes

The user should be able to learn the following after performing this experiment:

- 1. Linear Search can be used to search for items a sorted list** In cases where the list is sorted, the linear search strategy is still applicable.
- 2. Can be used as a baseline** Linear Search can be used as a baseline to compare other algorithms like binary search.

3.5 Binary Search

3.5.1 Objective

The objective of this experiment is to demonstrate the process of searching for an item in a sorted/ordered list using the binary search strategy.

3.5.2 Learning Outcomes

The user should be able to learn the following after performing this experiment:

- 1. Refinement of random search without replacement** Instead of randomly selecting items to compare, binary search strategy makes use of the sorted nature of the list to pick the next item to compare.
- 2. Identify the recursive sub-structure** The binary search strategy reduces the search space by recursively dividing the list into two halves such that the item (if present) is guaranteed to be in one half due to the list being sorted.
- 3. Termination** The binary search algorithm terminates when either the item is found, or when search space is reduced to empty list.