Recursive Backtracking

Definition (Recursive Backtracking)

Recursive Backtracking is an attempt to find solution(s) by building up partial solutions and abandoning them if they don’t work.

Recursive Backtracking Strategy

- If we found a solution, stop looking (e.g. return)
- Otherwise for each possible choice $c$...
  - Make the choice $c$
  - Recursively continue to make choices
  - Un-make the choice $c$ (if we got back here, it means we need to continue looking)

NQueens Problem

The NQueens problem is the challenge to place $n$ queens on a chess board so that none of them are attacking each other.

We will begin by solving this problem using for loops, and then we will solve it much more elegantly using recursive backtracking.

Implementing a Tiny Piece of Google

When you enter a query with no spaces like thisisasentence into Google:

It fixes it into this is a sentence using recursive backtracking.

Sentence Splitting

Given an input string, sentence, containing no spaces, write a method:

```java
public static String splitSentence(String sentence)
```

that returns sentence split up into words.
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To do recursive backtracking, we need to answer these questions:
- What are the choices we're making incrementally?
- How do we "undo" a choice?
- What are the base case(s)?

It helps to answer these questions for a particular input. So, pretend we're working with:

```
thisisasentence
```

One More Important Choice

When doing recursive backtracking, we need to differentiate between:
- finding a result
- failing to find a result (e.g., backtracking)

Generally, we do this by treating null as a failure. For example:
- On the input, "thisisasentence", none of the recursive calls should return "thisis", because it isn't a word.
- If we get down to an empty string, that would indicate a failure; so, we'd return null

Sentence Splitter Solution

```java
public String splitSentence(String sentence) {
    // The entire sentence is a dictionary word!
    if (words.contains(sentence)) {
        return sentence;
    }

    // Try splitting at every character until we find one that works...
    for (int i = sentence.length() - 1; i > 0; i--){
        String left = sentence.substring(0, i);
        String right = sentence.substring(i, sentence.length());

        // If the left isn't a word, don't bother recursing.
        // If it is, split the remainder of the sentence recursively.
        if (words.contains(left)) {
            // Since the left was a word, if the right is also an answer,
            // then we found an answer to the whole thing!
            if (right != null) {
                return left + " " + right;
            }
        }

        // Undo our choice by going back to sentence
    }

    return null;
}
```