

Set Theory and Computer Science

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A Quick Intro to Programming

- Computer programming consists of designing, testing, and maintaining code for computer programs and computer software.
- The code can be written in one or more languages.
 - Java, C++, Python, etc.
- Each language has different ways of communicating the code to a machine, just like human languages are communicated differently.
 - For example a print statement in
Java: `System.out.println("Hello");`
C++: `cout << "Hello";`
- Although I will be using Java, set theory is not limited to this programming language.

Sets in Java

- In Java, there are objects called Sets that hold other objects.
- Some types of sets are Collection, List, HashSet, TreeSet, etc.
- For the purpose demonstrating Sets, I will be using a type of list called and ArrayList.

Why ArrayLists?

- ArrayLists can hold any type of object. So if you want a set $A = \{\text{cat}, \text{dog}, \text{pig}\}$ and a set $B = \{1, 2, 3\}$, ArrayLists are able to handle both.
- ArrayLists also have practical operations that are similar to mathematical sets and can be applied:
 - `.size()` - this returns an integer value for the size of a set. This is can be related to the cardinality of a set.
 - `.remove(index)` - removes the element of the list at the specified index. This is useful for doing $A-B$.
 - `.contains(element)` - this checks to see if the list contains the specified element. This is useful for union and intersection operations.

Applet

Some Code in Action:

Cardinality:

```
if(e.getSource() == cardinalityA){
    if(A!=null){
        int cardA = A.length;
        display.setText("|A| = "+cardA);
    }
}
```

Union:

```
if(e.getSource()==union){
    if(A!=null && B!=null){
        ArrayList<Integer> temp = new ArrayList<Integer>();
        for(int i = 0; i < A.length; i++)
            temp.add(A[i]);
        for(int j = 0; j < B.length; j++)
            if(!temp.contains(B[j]))
                temp.add(B[j]);
        int[] U = new int[temp.size()];
        for(int n = 0; n < U.length; n++)
            U[n] = temp.get(n);

        String u="{ " + U[0] ;
        for(int i = 1; i<U.length; i++)
            u = u + ", "+U[i];
        u+="}";

        display.setText("A "+ u+" B = "+u);
    }
}
```

Applications

- A basic example of using set theory and computer science would be a program that handles clients for sales or games.
- A more complex example would be Kruskal's maze building algorithm (used in CS 301).

Kruskal's Algorithm in Action

A	B	C
D	E	F
G	H	I

- 3x3 maze. Each cell in the maze is assigned to a Set: A,B,C,D,E,F,G,H,I
- Select any cell at random. (E) and any of its neighboring cells at random (F). Now join them into the same set.

continued...

A	B	C
D	E	E
G	H	I

- We repeat this process until all of the cells belong to the same set.
- If you pick a cell and a neighbor at random that are already in the same set, don't do anything.

continued...

A	B	C
D	E	E
H	H	I

A	B	C
A	E	E
H	H	I

A	B	C
A	E	E
A	A	I

A	E	C
A	E	E
A	A	I

A	E	E
A	E	E
A	A	I

A	E	E
A	E	E
A	A	E

Finished product

E	E	E
E	E	E
E	E	E

Limitations

- Computers have a limited amount of memory, so we can never use infinite sets.
- Since computers are limited to memory, they also can't work with extremely large integer values.
- They also can't use numbers with a large number of decimals.

Thank You for Your Time!

