

Course Name: M. Tech

Semester: 2nd

Paper Name: Object Oriented Software Engineering (MTCS-203B)

Topic: Halstead's Software Science.

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Halstead's complexity measurement was developed to measure a program module's complexity directly from source code, with emphasis on computational complexity.

The Halstead's measures are based on four scalar number derived directly from a program's source code:

n_1 is number of distinct operators.

n_2 is number of distinct operands.

N_1 is total number of distinct operators.

N_2 is total number of distinct operands.

From these numbers, five measures are derived:

Measure	Symbol	Formula
Program length	N	$N = N_1 + N_2$
Program vocabulary	n	$n = n_1 + n_2$
Volume	V	$V = N * (\log_2 n)$
Difficulty	D	$D = (n_1 / 2) * (N_2 / 2)$
Effort	E	$E = D * V$

Halstead's uses certain measures such as program length, program vocabulary, volume, difficulty, and effort for the given algorithm. By this Halstead's is trying to show that the program length can be calculated, volume of algorithm can be estimated. The above given table shows how actually these measure can be obtained.

The Halstead's measures are applicable to operational system and to development efforts once the code has been written. Thus using Halstead's measurement experimental verification can be performed in software science.

Program length:

The length of a program is total usage of operators and operands in the program.

$$\text{Length (N)} = N_1 + N_2$$

Program vocabulary:

The Program vocabulary is the number of unique operators and operands used in the program.

$$\text{Vocabulary (n)} = n_1 + n_2$$

Program Volume:

The Program Volume can be defined as minimum number of bits needed to encode the program.

$$\text{Volume (V)} = N \log_2 n$$

Length estimation:

$$N = n_1 \log_2 n_1 + n_2 \log_2 n_2$$

Guideline for calculating operands and operators:

1. All the variables and constants are considered as operands.
2. Local variables with same name, if occurring in different functions are counted as unique operand.
3. Function calls are considered as operators.

4. The looping statements, do ... while, while, for, are operators. The statements if, if ... else, are operators. The switch ... case statements are considered as operators.
5. The reserve words, returns, default, continue, break, sizeof are all operators.
6. The brackets, commas, semicolons, are operators.
7. The unary and binary operators are considered as operators. The & is considered as operator.
8. In arrays, array name and index are considered as operands and [] is considered as operator.
9. All hash directives can be ignored.
10. Comments are not considered.
11. In Goto statement, goto is considered as operator and label as operand.

Example: Obtain Halstead's length and volume measure for following C function.

```
Void swap (int a[ ], int i)
```

```
{
int temp;
Temp = a[i];
a[i] = a[i+1];
a[i+1] = temp;
}
```

We first find out the operands and operators from above function along with their occurrences.

Operands	Occurrences	Operators	Occurrences
swap	1	()	1
a	5	{ }	1
i	5	void	1
temp	3	int	3
1	2	[]	5

		,	1
		;	4
		=	3
		+	2
$n_1 = 5$	$N_1 = 16$	$n_2 = 9$	$N_2 = 21$

$$N = N_1 + N_2$$

$$= 16 + 21 = 37$$

$$N = 37$$

$$n = n_1 + n_2$$

$$= 5 + 9 = 14$$

$$n = 14$$

$$\text{Estimated length} = n_1 \log n_1 + n_2 \log n_2$$

$$= 5 \log 5 + 9 \log 9$$

$$= 5 * 2.32 + 9 * 2.19 = 31.37$$

$$\text{Estimated length} = 31.37$$

$$\text{Volume} = N * \log n$$

$$= 37 * \log (14)$$

$$37 * 2.63 = 97.64$$

$$\text{Volume (V)} = 97.64$$