Classification of Codes

In this section we look at to classify codes according to the following categories.

1. Fixed Length Codes
2. Variable Length Codes
3. Distinct Codes
4. Prefix-Free Codes
5. Uniquely decodable codes
6. Instantaneous Codes
7. Optimal Codes

Classification of Codes

Classification of codes is best illustrated by an example. Consider the table below where a source of size 4 has been encoded in binary codes with symbol 0 and 1.

X	Code 1	Code 2	Code 3	Code 4	Code 5	Code 6
x_1	00	00	0	0	0	1
x_2	01	01	1	10	01	01
x_3	00	10	00	110	011	001
x_4	11	11	11	111	0111	0001

1. Fixed-Length Codes: A fixed-length code is one whose code word length is fixed. Code 1 and code 2are fixed-length codes with length 2.
2. Variable-Length Codes: A variable-length code is one whose code word length is not fixed. All codes except codes 1 and 2 are variable-length codes.
3. Distinct Codes: A code is distinct if each code word is distinguishable from other code words. All codes except code 1 are distinct codes. Notice the codes for x_l and x_3.
4. Prefix-Free Codes: A code in which no code word can be formed by adding code symbols to another code word is called a prefix-free code. Thus, in a prefix-free code no code word is a prefix of another. Codes 2, 4, and 6 are prefix-free codes.

5. Uniquely Decodable Codes

- A distinct code is uniquely decodable if the original source sequence can be reconstructed perfectly from the encoded binary sequence.
- Note that code 3 is not a uniquely decodable code.
- For example, the binary sequence 1001 may correspond to the source sequences $x_2x_3x_2$ or $x_2x_1x_1x_2$.
- A sufficient condition to ensure that a code is uniquely decodable is that no code word is a prefix of another.
- Thus, the prefix-free codes 2, 4, and 6 are uniquely decodable codes. Note that the prefix -free condition is not a necessary condition for unique decodability.
- For example, code 5 does not satisfy the prefix-free condition, and yet it is uniquely decodable since the bit 0 indicates the beginning of each code word of the code.

6. Instantaneous Codes
   - A uniquely decodable code is called an instantaneous code if the end of any code word is recognizable without examining subsequent code symbols.
   - The instantaneous codes have the property previously mentioned that no code word is a prefix of another code word.
7. Optimal Codes
   - A code is said to be optimal if it is instantaneous and has minimum average length L for a given source with a given probability assignment for the source symbols.