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Assignment Lesson 09

Question

1) Find encoder and decoder of LZW? If we have:

Input string: “abdcaedbdcecabb”

2) Find encoder and decoder of LZW? If we have:

Input string: “cdaabbefacbdegfeeggf”

Answers

1). Find encoder and decoder of LZW

Given if we have: Input string: “abdcaedbdcecabb”

- Encoder: First, we find all different characters.

  There are “a,b,c,d,e”

  Then build a base dictionary table:

Entry	Codeword
a	1
b	2
c	3
d	4
e	5

Next, Build an output dictionary we got:

a b d c a e d b d c e c a b b EOF

- s = 'a', c = 'b',
- since 'ab' is not in the dictionary,
- output codeword for 'a' (1),
- add 'ab' to dictionary with codeword 6.
- s = 'b', c = 'd',
- since 'bd' is not in the dictionary,

- output codeword for 'b' (2),
- add 'bd' to dictionary with codeword 7.
- s = 'd', c = 'c', since 'dc' is not in the dictionary,
- output codeword for 'd' (4),
- add 'dc' to dictionary with codeword 8.
- s = 'c', c = 'a',
- since 'ca' is not in the dictionary,
- output codeword for 'c' (3),
- add 'ca' to dictionary with codeword 9.
- s = 'a', c = 'e',
- since 'ae' is not in the dictionary,
- output codeword for 'a' (1),
- add 'ae' to dictionary with codeword 10.
- s = 'e', c = 'd',
- since 'ed' is not in the dictionary,
- output codeword for 'e' (5),
- add 'ed' to dictionary with codeword 11.
- s = 'd', c = 'b',
- since 'db' is not in the dictionary,
- output codeword for 'd' (4),
- add 'db' to dictionary with codeword 12.
- s = 'b', c = 'd',
- since 'bd' is already in the dictionary,
- set s to 'bd' and move to the next c which is 'c'.
- s = 'bd', c = 'c',
- since 'bdc' is not in the dictionary,
- output codeword for 'bd' (7),
- add 'bdc' to dictionary with codeword 13.
- s = 'c', c = 'e',
- since 'ce' is not in the dictionary,

- output codeword for 'c' (3),
- add 'ce' to dictionary with codeword 14.
- s = 'e', c = 'c',
- since 'ec' is not in the dictionary,
- output codeword for 'e' (5),
- add 'ec' to dictionary with codeword 15.
- s = 'c', c = 'a',
- since 'ca' is already in the dictionary,
- set s to 'ca' and move to the next c which is 'b'.
- s = 'ca', c = 'b',
- since 'cab' is not in the dictionary,
- output codeword for 'ca' (9),
- add 'cab' to dictionary with codeword 16.
- s = 'b', c = 'b', since 'bb' is not in the dictionary,
- output codeword for 'b' (2),
- add 'bb' to dictionary with codeword 17.
- s = 'b', since this is the last character,
- output codeword for 'b' (2), and we reach EOF.

s	c	Item	Codeword	Output
a	b	ab	6	1
b	d	bd	7	2
d	c	dc	8	4
c	a	ca	9	3
a	e	ae	10	1
e	d	ed	11	5
d	b	db	12	4
bd	c	bdc	13	7
c	e	ce	14	3
e	c	ec	15	5
ca	b	cab	16	9
b	b	bb	17	2
b	EOF	-	-	2

Thus, encoder is {1, 2, 4, 3, 1, 5, 4, 7, 3, 5, 9, 2, 2}

- Deconder : Input string is the result of encoder.

  String = 1 2 4 3 1 5 4 7 3 5 9 2 2 EOF

- Output dictionary:

  - Step 1:

    ➢ s = null and k = 1.

    ➢ entry = "a" (codeword 1 → "a").

    ➢ k is in the base dictionary.

    ➢ Output entry ("a"). s is empty.

    ➢ s = entry = "a".

  - Step 2:

    ➢ s = "a" and k = 2.

    ➢ entry = "b" (codeword 2 → "b").

    ➢ k is in the base dictionary.

    ➢ Output entry ("b"). s is not empty.

    ➢ Add s + entry[0] = "ab". s = entry = "b".

  - Step 3:

    ➢ s = "b" and k = 4.

    ➢ entry = "d" (codeword 4 → "d").

    ➢ k is in the base dictionary.

    ➢ Output entry ("d"). s is not empty.

    ➢ Add s + entry[0] = "bd". s = entry = "d".

  - Step 4:

    ➢ s = "d" and k = 3.

    ➢ entry = "c" (codeword 3 → "c").

    ➢ k is in the base dictionary.

➢ Output entry ("c"). s is not empty.

➢ Add s + entry[0] = "dc". s = entry = "c".

- Step 5:

➢ s = "c" and k = 1.

➢ entry = "a" (codeword 1 → "a").

➢ k is in the base dictionary.

➢ Output entry ("a"). s is not empty.

➢ Add s + entry[0] = "ca". s = entry = "a".

- Step 6:

➢ s = "a" and k = 5.

➢ entry = "e" (codeword 5 → "e").

➢ k is in the base dictionary.

➢ Output entry ("e"). s is not empty.

➢ Add s + entry[0] = "ae". s = entry = "e".

- Step 7:

➢ s = "e" and k = 4.

➢ entry = "d" (codeword 4 → "d").

➢ k is in the base dictionary.

➢ Output entry ("d"). s is not empty.

➢ Add s + entry[0] = "ed". s = entry = "d".

- Step 8:

➢ s = "d" and k = 7.

➢ entry = "bd" (codeword 7 → "bd", created in Step 3).

➢ k is not in the base dictionary, it was added in a previous step.

➢ Output entry ("bd"). s is not empty.

➢ Add s + entry[0] = "db". s = entry = "bd".

- Step 9:

➢ s = "bd" and k = 3.

➢ entry = "c" (codeword 3 → "c").

➢ k is in the base dictionary.

➢ Output entry ("c"). s is not empty.

➢ Add s + entry[0] = "bdc". s = entry = "c".

- Step 10:

➢ s = "c" and k = 5.

➢ entry = "e" (codeword 5 → "e").

➢ k is in the base dictionary.

➢ Output entry ("e"). s is not empty.

➢ Add s + entry[0] = "ce". s = entry = "e".

- Step 11:

➢ s = "e" and k = 9.

➢ Since k = 9 has not been encountered before, this is a special case where entry is s + s[0] = "ee".

➢ Output entry ("ee"). s is not empty.

➢ Add s + entry[0] = "ee". s = entry = "ee".

- Step 12:

➢ s = "ee" and k = 2.

➢ entry = "b" (codeword 2 → "b").

➢ k is in the base dictionary.

➢ Output entry ("b"). s is not empty.

➢ Add s + entry[0] = "eeb". s = entry = "b".

- Step 13:

➢ s = "b" and k = 2.

➢ entry = "b" (codeword 2 → "b").

➢ k is in the base dictionary.

➢ Output entry ("b"). s is not empty.

➢ Add s + entry[0] = "bb". s = entry = "b".

- Final Step:

➢ s = "b" and k = EOF.

➢ Since k = EOF, the decoding process is complete.

s	k	Item	Codeword	Output
null	1	a	1	a
a	2	ab	6	b
b	4	bd	7	d
d	3	dc	8	c
c	1	ca	9	a
a	5	ae	10	e
e	4	ed	11	d
d	7	db	12	bd
bd	3	bdc	13	c
c	5	ce	14	e
e	9	ec	15	ca
ca	2	cab	16	b
b	2	bb	17	b
b	EOF	-	-	-

Thus, decoder is “abdcaedbdcecabb”

2). Find encoder and decoder of LZW?

Given if we have: Input string: “cdaabbefacbdegfeeggf”

- Encoder: First, we find all different characters.
- There are “abcdefg”

- Build a base dictionary table:

Entry	Codeword
a	1
b	2
c	3
d	4
e	5
f	6
g	7

- s = 'c', c = 'd'
- s + c = 'cd' does not exist in the dictionary.
- Output codeword of s ('c' → 3).
- Add 'cd' to the dictionary. New codeword is 8.
- s = c = 'd'.

- s = 'd', c = 'a'
- s + c = 'da' does not exist in the dictionary.
- Output codeword of s ('d' → 4).
- Add 'da' to the dictionary. New codeword is 9.
- s = c = 'a'.

- s = 'a', c = 'a'
- s + c = 'aa' does not exist in the dictionary.
- Output codeword of s ('a' → 1).
- Add 'aa' to the dictionary. New codeword is 10.
- s = c = 'a'.

- s = 'a', c = 'b'
- s + c = 'ab' does not exist in the dictionary.
- Output codeword of s ('a' → 1).
- Add 'ab' to the dictionary. New codeword is 11.
- s = c = 'b'.

- s = 'b', c = 'b'
- s + c = 'bb' does not exist in the dictionary.
- Output codeword of s ('b' → 2).
- Add 'bb' to the dictionary. New codeword is 12.
- s = c = 'b'.

- s = 'b', c = 'e'
- s + c = 'be' does not exist in the dictionary.
- Output codeword of s ('b' → 2).

- Add 'be' to the dictionary. New codeword is 13.
- s = c = 'e'.

- s = 'e', c = 'f'
- s + c = 'ef' does not exist in the dictionary.
- Output codeword of s ('e' → 5).
- Add 'ef' to the dictionary. New codeword is 14.
- s = c = 'f'.

- s = 'f', c = 'a'
- s + c = 'fa' does not exist in the dictionary.
- Output codeword of s ('f' → 6).
- Add 'fa' to the dictionary. New codeword is 15.
- s = c = 'a'.

- s = 'a', c = 'c'
- s + c = 'ac' does not exist in the dictionary.
- Output codeword of s ('a' → 1).
- Add 'ac' to the dictionary. New codeword is 16.
- s = c = 'c'.

- s = 'c', c = 'b'
- s + c = 'cb' does not exist in the dictionary.
- Output codeword of s ('c' → 3).
- Add 'cb' to the dictionary. New codeword is 17.
- s = c = 'b'.

- s = 'b', c = 'd'
- s + c = 'bd' does not exist in the dictionary.
- Output codeword of s ('b' → 2).
- Add 'bd' to the dictionary. New codeword is 18.
- s = c = 'd'.

- s = 'd', c = 'e'
- s + c = 'de' does not exist in the dictionary.
- Output codeword of s ('d' → 4).
- Add 'de' to the dictionary. New codeword is 19.
- s = c = 'e'.

- s = 'e', c = 'g'
- s + c = 'eg' does not exist in the dictionary.
- Output codeword of s ('e' → 5).
- Add 'eg' to the dictionary. New codeword is 20.
- s = c = 'g'.

- s = 'g', c = 'f'
- s + c = 'gf' does not exist in the dictionary.
- Output codeword of s ('g' → 7).
- Add 'gf' to the dictionary. New codeword is 21.
- s = c = 'f'.

- s = 'f', c = 'e'
- s + c = 'fe' does not exist in the dictionary.
- Output codeword of s ('f' → 6).
- Add 'fe' to the dictionary. New codeword is 22.
- s = c = 'e'.

- s = 'e', c = 'e'
- s + c = 'ee' does not exist in the dictionary.
- Output codeword of s ('e' → 5).
- Add 'ee' to the dictionary. New codeword is 23.
- s = c = 'e'.

- s = 'eg', c = 'g'
- s + c = 'egg' does not exist in the dictionary.
- Output codeword of s ('eg' → 20).
- Add 'egg' to the dictionary. New codeword is 24.
- s = c = 'g'.

- s = 'gf', c = 'EOF'
- s + c = 'gf' does not exist in the dictionary (since it's EOF, we don't add to the dictionary).
- Output codeword of s ('gf' → 21).

s	c	Item	Codeword	Output
c	d	cd	8	3
d	a	da	9	4
a	a	aa	10	1
a	b	ab	11	1
b	b	bb	12	2
b	e	be	13	2
e	f	ef	14	5
f	a	fa	15	6
a	c	ac	16	1
c	b	cb	17	3
b	d	bd	18	2

d	e	de	19	4
e	g	eg	20	5
g	f	gf	21	7
f	e	fe	22	6
e	e	ee	23	5
eg	g	egg	24	20
gf	EOF	-	-	21

Thus, encoder is : {3, 4, 1, 1, 2, 2, 5, 6, 1, 3, 2, 4, 5, 7, 6, 5, 20, 21}

➢ s='' and k=3.

➢ entry = 'c' (codeword 3→'c').

➢ k is in the base dictionary.

➢ Output entry ('c'). s is not empty.

➢ Add s+entry[0]='c' if s is not empty. s = entry = 'c'.

➢ s='c' and k=4.

➢ entry = 'd' (codeword 4→'d').

➢ k is in the base dictionary.

➢ Output entry ('d'). s is not empty.

➢ Add s+entry[0]='cd' if s is not empty. s = entry = 'd'.

➢ s='d' and k=1.

➢ entry = 'a' (codeword 1→'a').

➢ k is in the base dictionary.

➢ Output entry ('a'). s is not empty.

➢ Add s+entry[0]='da' if s is not empty. s = entry = 'a'.

➢ s='a' and k=1.

➢ entry = 'a' (codeword 1→'a').

➢ k is in the base dictionary.

➢ Output entry ('a'). s is not empty.

➢ Add s+entry[0]='aa' if s is not empty. s = entry = 'a'.

➢ s='a' and k=2.

➢ entry = 'b' (codeword 2→'b').

➢ k is in the base dictionary.

➢ Output entry ('b'). s is not empty.

➢ Add s+entry[0]='ab' if s is not empty. s = entry = 'b'.

➢ s='b' and k=2.

➢ entry = 'b' (codeword 2→'b').

➢ k is in the base dictionary.

➢ Output entry ('b'). s is not empty.

➢ Add s+entry[0]='bb' if s is not empty. s = entry = 'b'.

➢ s='b' and k=5.

➢ entry = 'e' (codeword 5→'e').

➢ k is in the base dictionary.

➢ Output entry ('e'). s is not empty.

➢ Add s+entry[0]='be' if s is not empty. s = entry = 'e'.

➢ s='e' and k=6.

➢ entry = 'f' (codeword 6→'f').

➢ k is in the base dictionary.

➢ Output entry ('f'). s is not empty.

➢ Add s+entry[0]='ef' if s is not empty. s = entry = 'f'.

➢ s='f' and k=1.

➢ entry = 'a' (codeword 1→'a').

➢ k is in the base dictionary.

➢ Output entry ('a'). s is not empty.

➢ Add s+entry[0]='fa' if s is not empty. s = entry = 'a'.

➢ s='a' and k=3.

➢ entry = 'c' (codeword 3→'c').

➢ k is in the base dictionary.

➢ Output entry ('c'). s is not empty.

➢ Add s+entry[0]='ac' if s is not empty. s = entry = 'c'.

➢ s='c' and k=2.

➢ entry = 'b' (codeword 2→'b').

➢ k is in the base dictionary.

➢ Output entry ('b'). s is not empty.

➢ Add s+entry[0]='cb' if s is not empty. s = entry = 'b'.

➢ s='b' and k=4.

➢ entry = 'd' (codeword 4→'d').

➢ k is in the base dictionary.

➢ Output entry ('d'). s is not empty.

➢ Add s+entry[0]='bd' if s is not empty. s = entry = 'd'.

➢ s='d' and k=5.

➢ entry = 'e' (codeword 5→'e').

➢ k is in the base dictionary.

➢ Output entry ('e'). s is not empty.

➢ Add s+entry[0]='de' if s is not empty. s = entry = 'e'.

➢ s='e' and k=7.

➢ entry = 'g' (codeword 7→'g').

➢ k is in the base dictionary.

➢ Output entry ('g'). s is not empty.

➢ Add s+entry[0]='eg' if s is not empty. s = entry = 'g'.

➢ s='g' and k=6.

➢ entry = 'f' (codeword 6→'f').

➢ k is in the base dictionary.

➢ Output entry ('f'). s is not empty.

➢ Add s+entry[0]='gf' if s is not empty. s = entry = 'f'.

➢ s='f' and k=5.

➢ entry = 'e' (codeword 5→'e').

➢ k is in the base dictionary.

➢ Output entry ('e'). s is not empty.

➢ Add s+entry[0]='fe' if s is not empty. s = entry = 'e'.

➢ s='e' and k=20.

➢ entry = 'eg' (codeword 20→'eg').

➢ k is in the base dictionary.

➢ Output entry ('eg'). s is not empty.

➢ Add s+entry[0]='ee' if s is not empty. s = entry = 'eg'.

➢ s='eg' and k=21.

➢ entry = 'gf' (codeword 21→'gf').

➢ k is in the base dictionary.

➢ Output entry ('gf'). s is not empty.

➢ Add s+entry[0]='egg' if s is not empty. s = entry = 'gf'.

- Decoder :

s	k	Item	Codeword	Output
null	3	c	-	c
c	4	cd	8	d
d	1	da	9	a
a	1	aa	10	a
a	2	ab	11	b
b	2	bb	12	b
b	5	be	13	e
e	6	ef	14	f
f	1	fa	15	a
a	3	ac	16	c
c	2	cb	17	b
b	4	bd	18	d
d	5	de	19	e
e	7	eg	20	g
g	6	gf	21	f
f	5	fe	22	e
e	20	ee	23	eg
eg	21	egg	24	gf
gf	EOF	-	-	-

Thus, Decoder is “cdaabbefacbdegfeggf”