

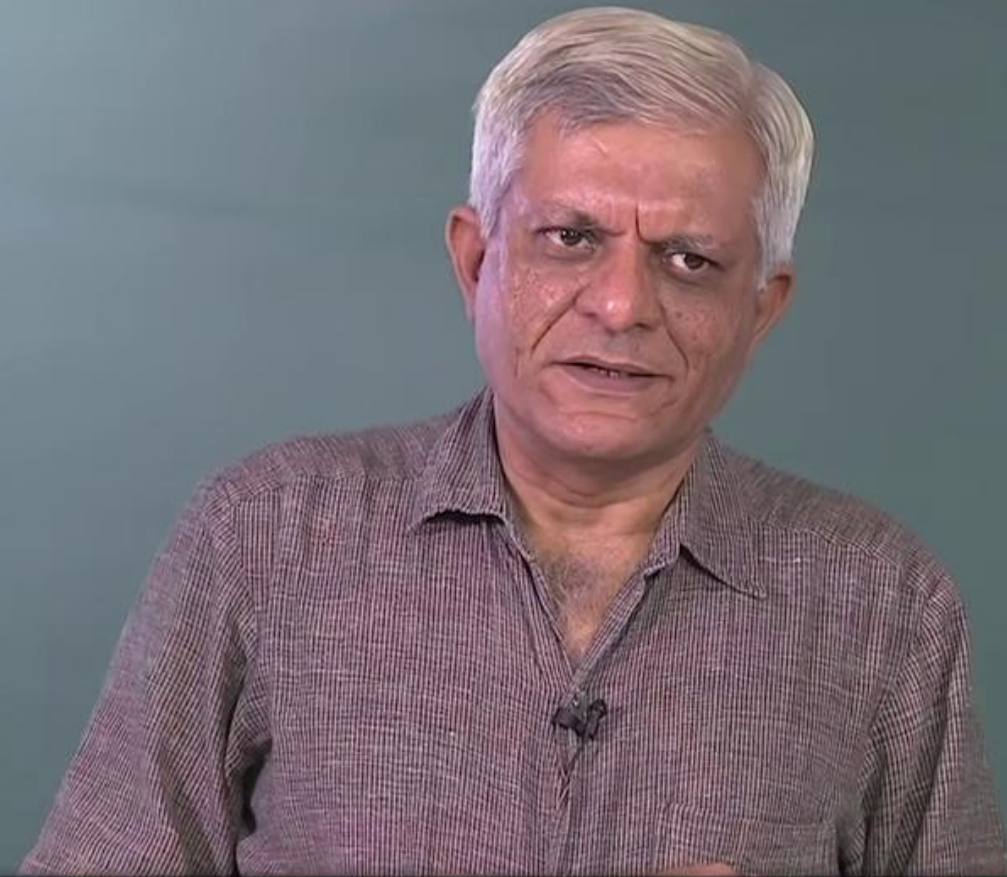
Video Lectures On Artificial Intelligence

Lecture 11 Solution Space Search , Beam Search

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Department of Computer Science and Engineering
IIT Madras





Prof . Deepak Khemani

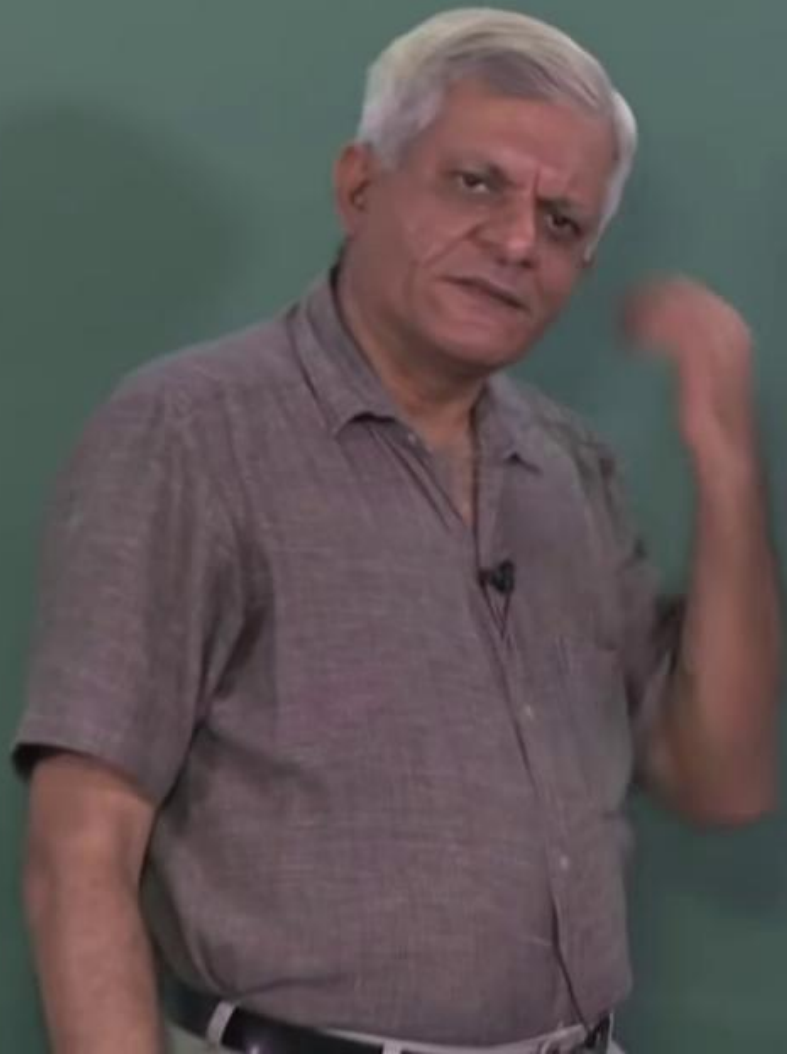
Dept . of . Computer Science and Engineering IIT Madras



ma

SAT

F



SAT

$$F = (a \vee b) \wedge (a \vee \neg c \vee b)$$

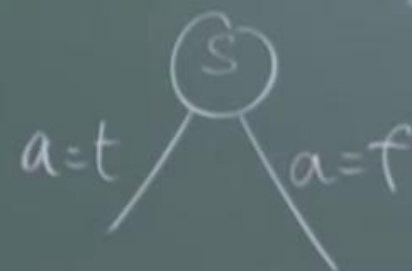
0 1 - -

anna

SAT

$$F = (a \vee b) \wedge (a \vee c) \wedge \dots$$

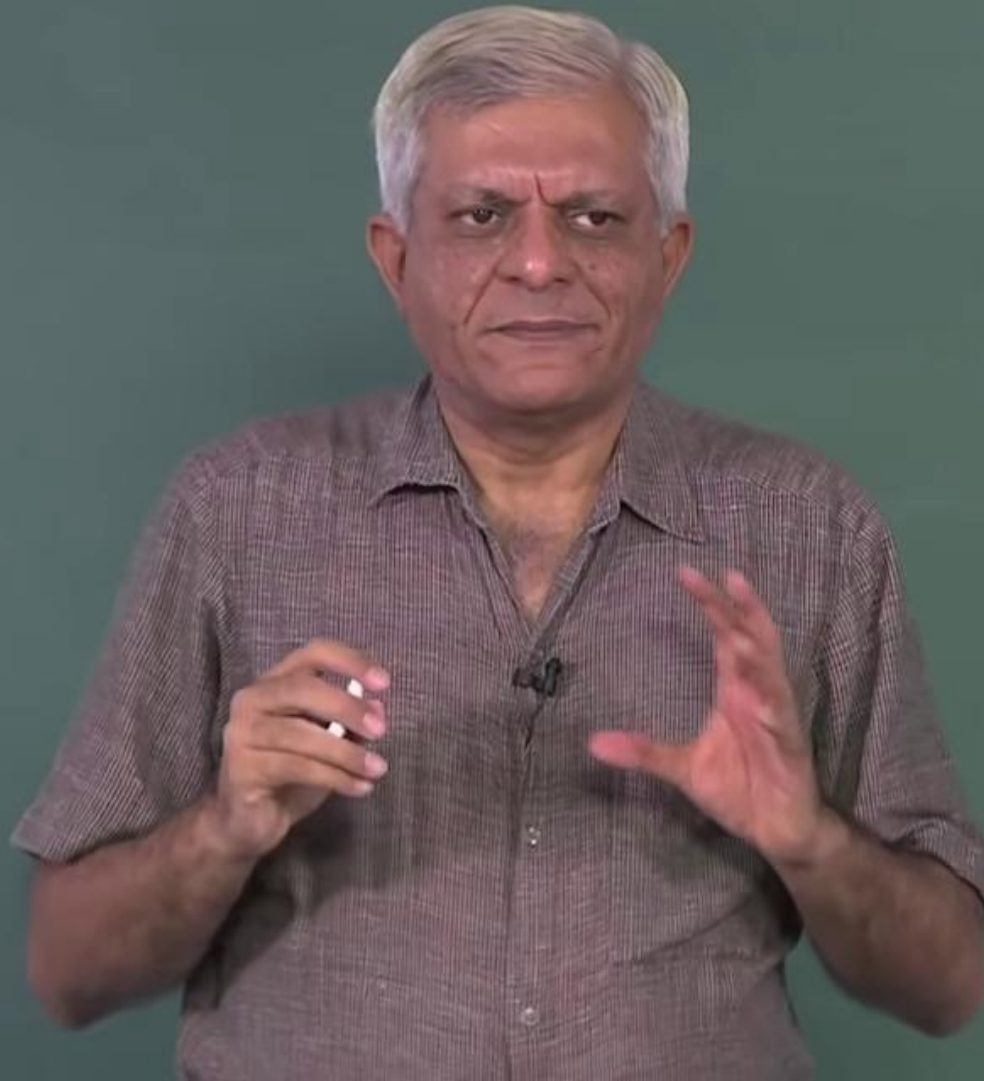
0.



From 1990 to 1995



Local search \rightarrow local maxima



na

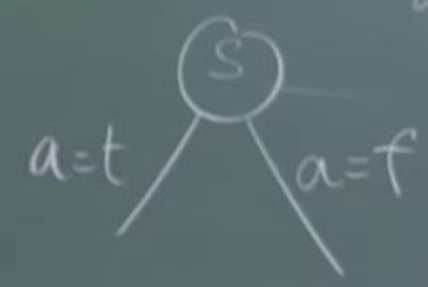
$var = \{a, b, c, d, e\}$

SAT

$F = (a \vee b) \wedge (a \vee c \vee d \vee e) \wedge \dots$

n variables

2^n states



var = {a, b, c, d, e}

SAT

$$F = (a \vee b) \wedge (a \vee \neg c \vee b)$$

n variables

$- 2^n$ states

n = 100?

$2^{100} \approx 10^{30}$ states



var = {a, b, c, d, e}

n variables

$- 2^n$ states

n = 100?

$2^{100} \approx 10^{30}$ states

SAT literal

$$F = \underbrace{(a \vee b)}_{\text{clause}} \wedge \underbrace{(a \vee \neg c \vee b)}_{\text{clause}}$$



Solution Space Search



Local Search \rightarrow Local maxima

Solution Space Search

10111

Solution Space Search
Perturbation.

10111

8-Queens

(6, 1, 3, 4, 5, 2)

space search
Perturbation

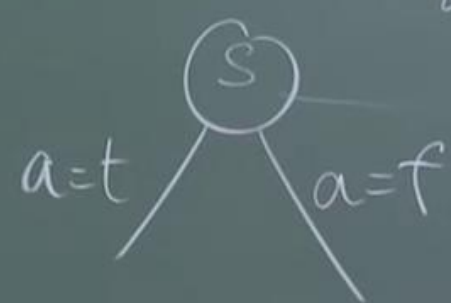
variables

-2^n states

$n = 100?$

$2^{100} \approx 10^{30}$ states

$$F = \frac{(a \vee b) \wedge (a \vee c)}{0 \dots \dots c}$$



6-Queens

(6, 1, 3, 4, 5, 2)

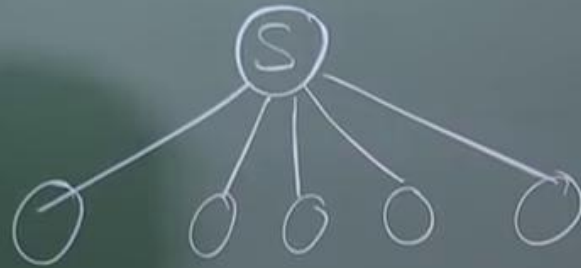
Solution Space Search

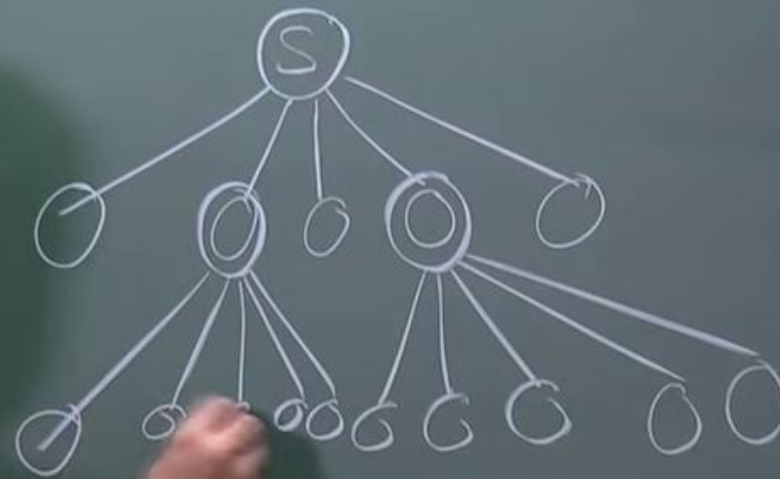
Perturbati

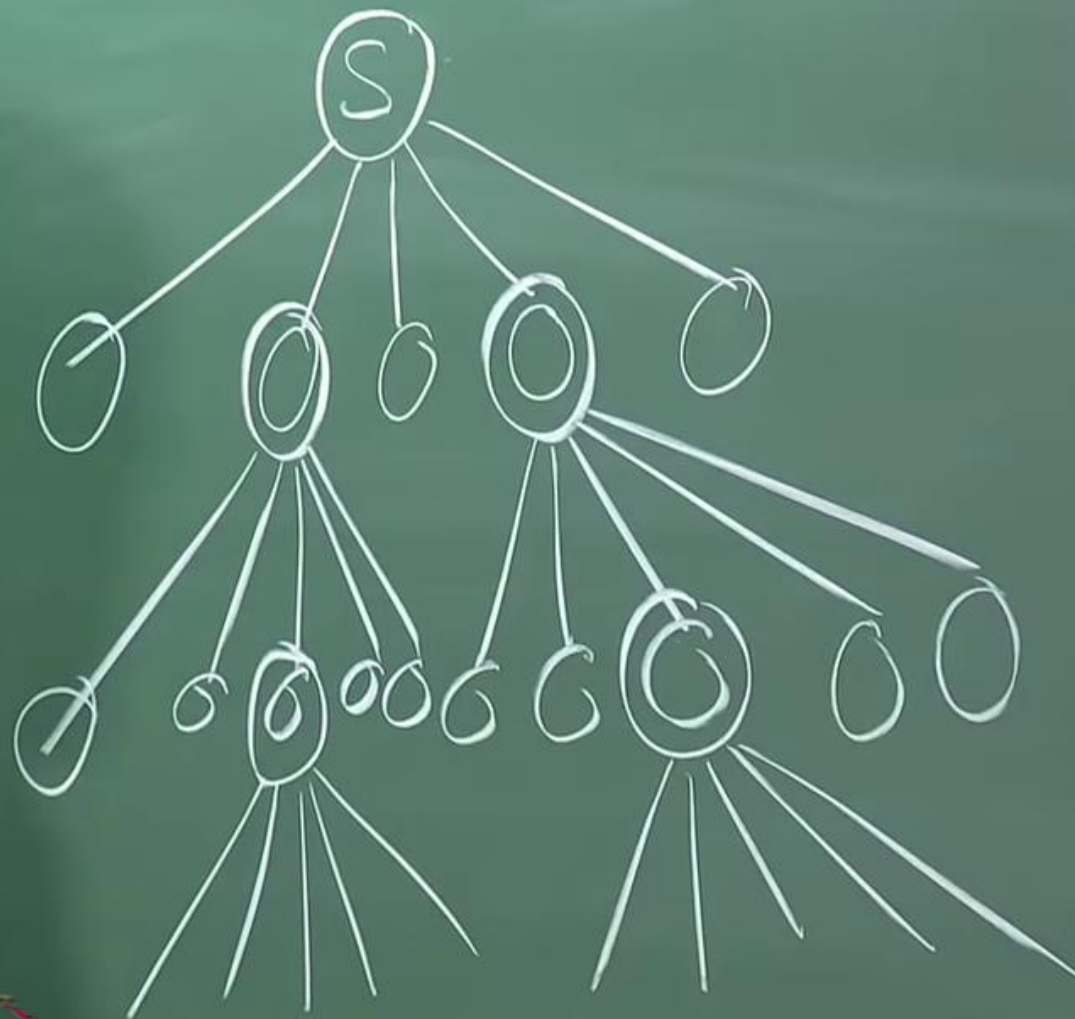
10111

N.

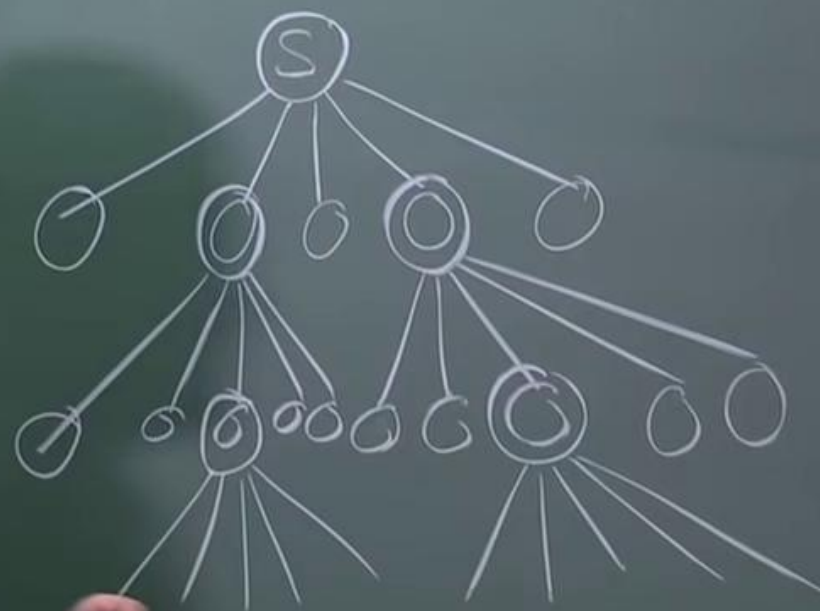




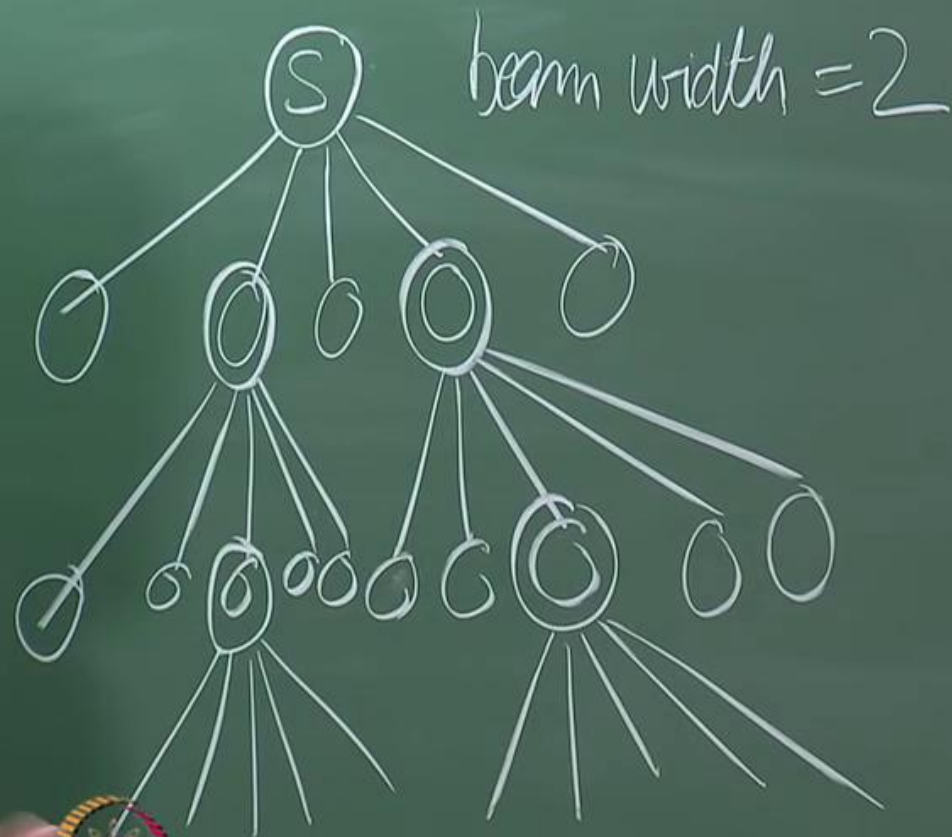




BEAM SEARCH



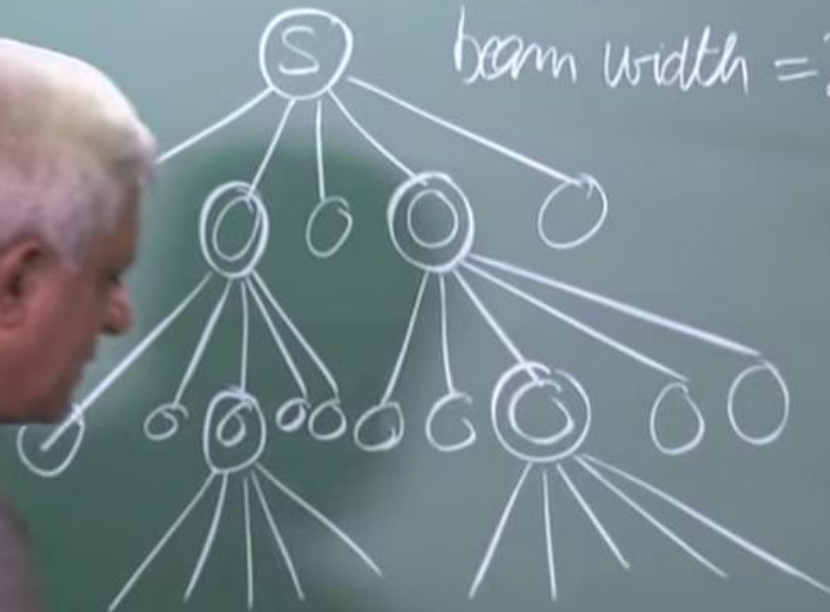
BEAM SEARCH



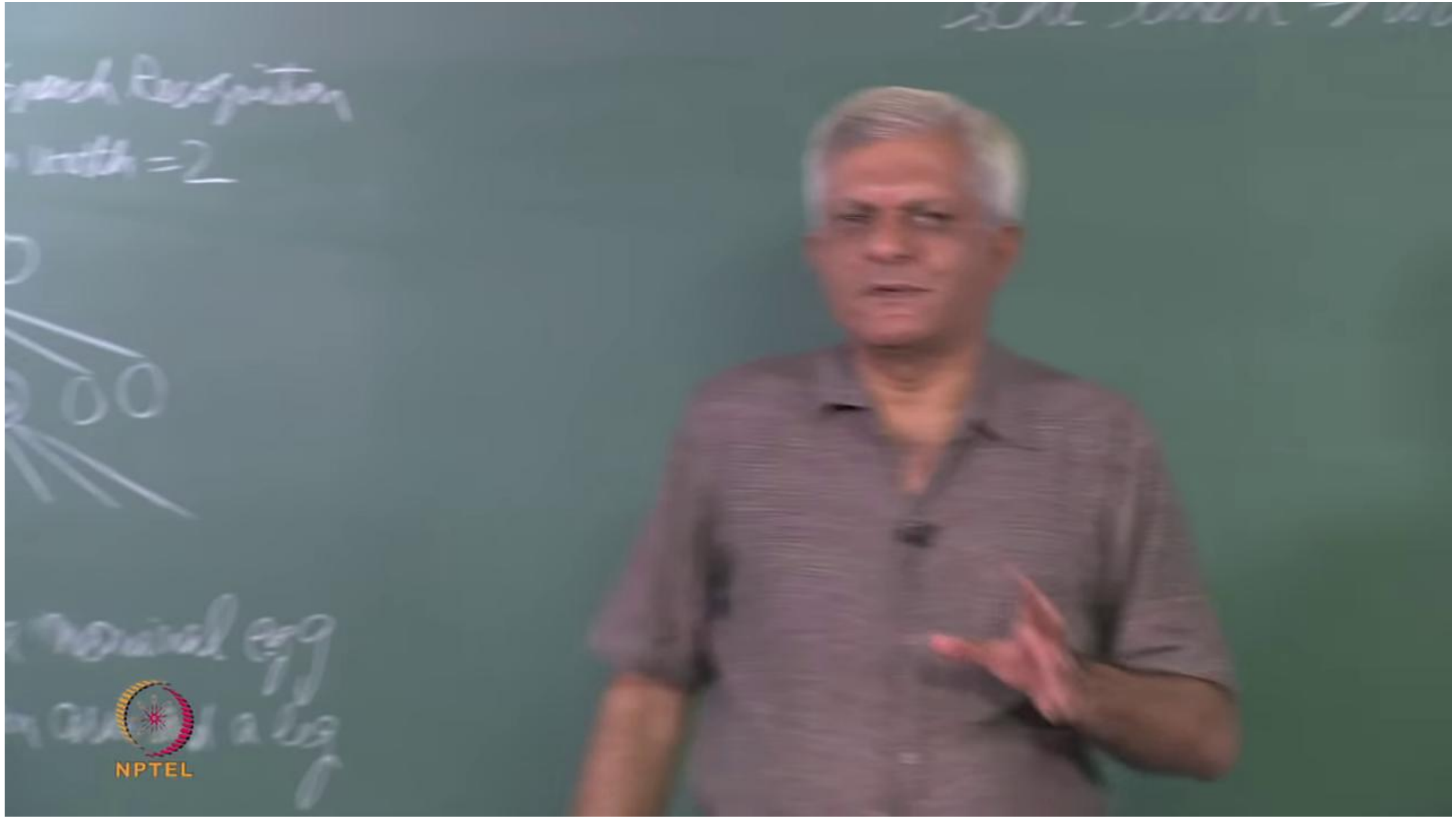
BEAM SEARCH

Speech Recognition

beam width = 2

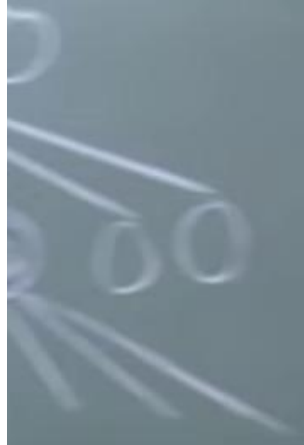


cost a nominal egg



Speech Recognition

width = 2



nominal egg

on a log

Some known facts

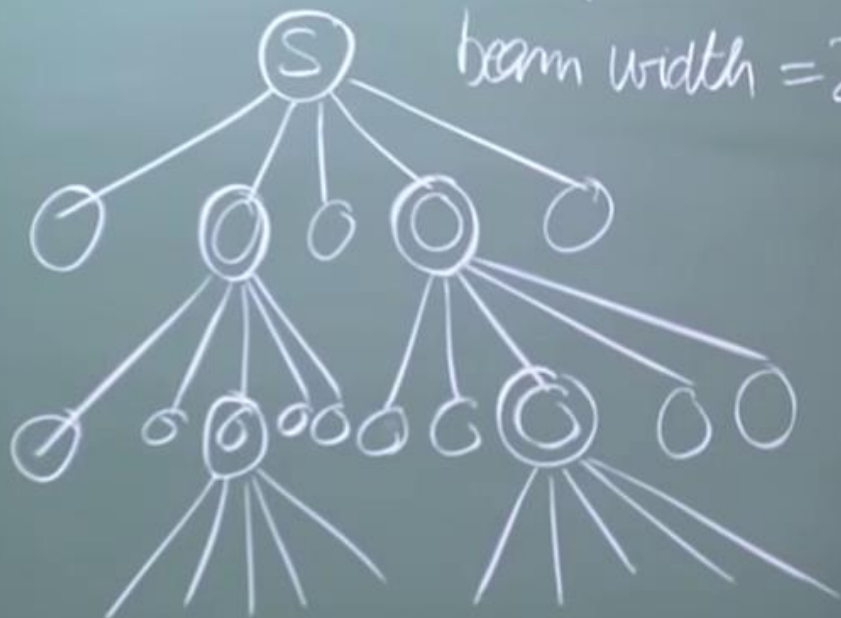


NPTEL

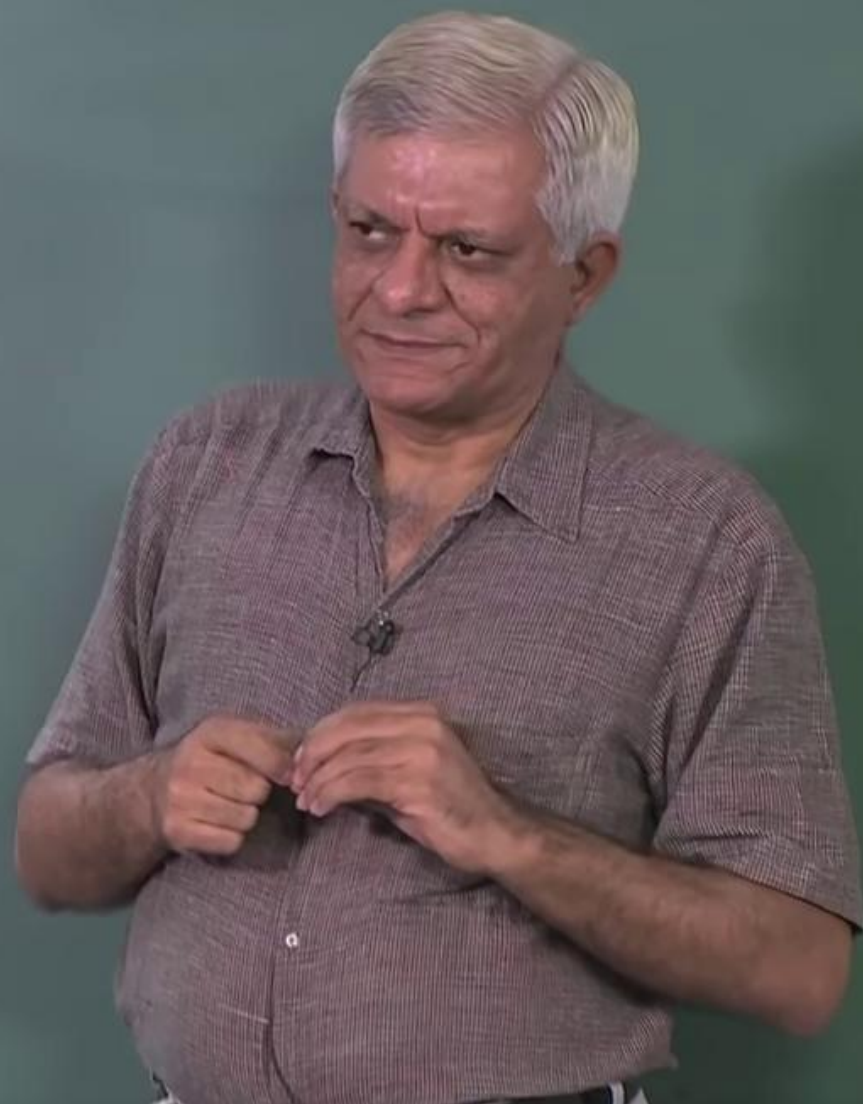
BEAM SEARCH

Speech Recognition

beam width = 2



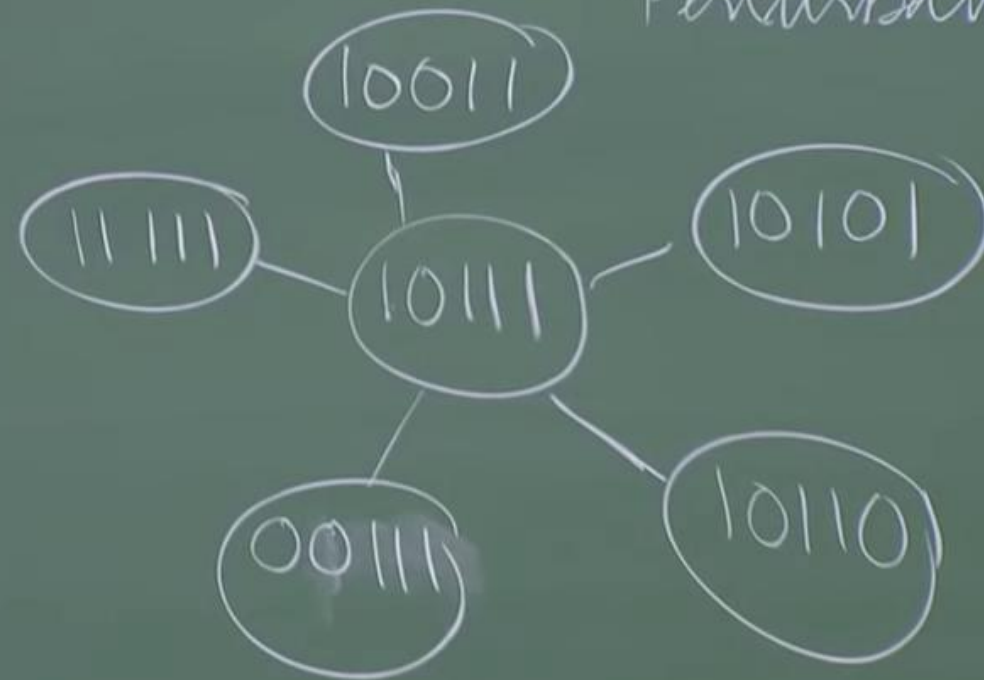
costs a nominal egg
costs an arm and a leg



Local search \rightarrow local maxima

Solution Space Search

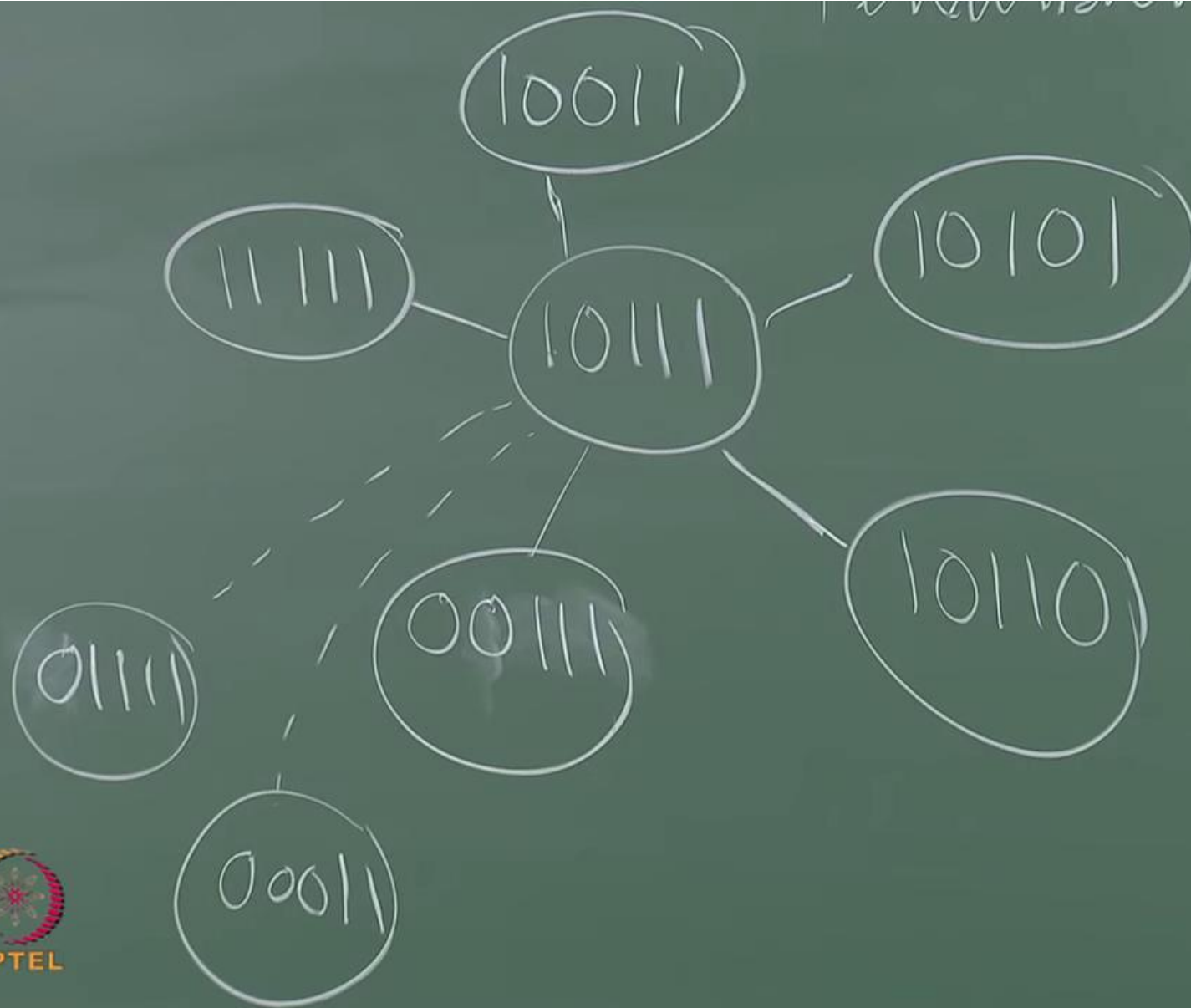
Perturbate



N_1 - change 1 bit

N_2 - change any 2 bits





$N_1 - 0$
 $N_2 - 0$

N_1 - change 1 bit

n_{C_2} - N_2 - change any 2 bits

01111

10110

n
 C_2

N_1 - change 1 bit

N_2 - change any 2 bits

N_{12345}

N_{12}

N_{123}

$N_{1 \dots n}$

more
dense

N_3

N_n



NPTEL

(111)

(10110)

N_1 - change 1 bit

N_2 - change any 2 bits

n_C

N_{123}

N_3

N_{12345}

more
dense

Neighborhood

$N_{1...n}$

N_n



NPTEL

(111)

(10110)

n_2

N_1 - change 1 bit

N_2 - change any 2 bits

N_{12}

N_{123}

N_{12345}

$N_{1 \dots n}$

more
dense
neighbourhood

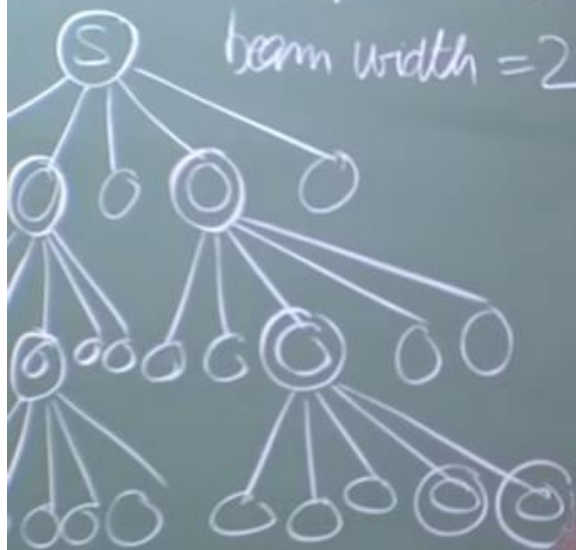
N_3

N_n



SEARCH VITERBI
Speech Recognition

beam width = 2



costs a node
costs an arc

Local Search \rightarrow local

(N_1, N_2, \dots)
increasing density

(0111)

a, b, c, d, e

nodes

2^n states

00?

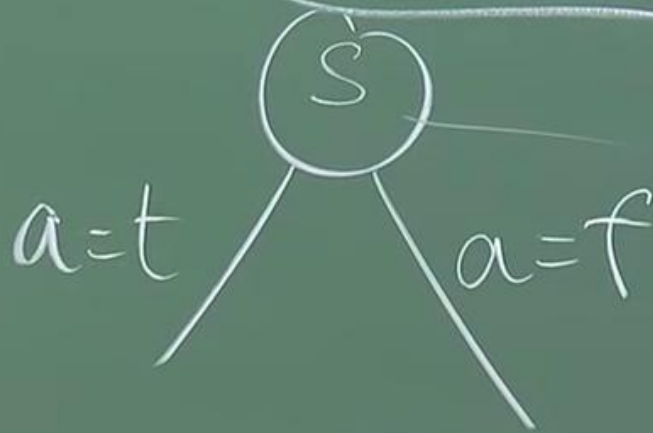
$2^{100} \approx 10^{30}$ states

but

$$F = (a \vee b) \wedge (a \vee \neg c \vee b)$$

0 1 ...

clause



$h(n) ?$



NPTEL

h Recognition
th = 2

(N_1, N_2, \dots)
increasing density

Solution Sp

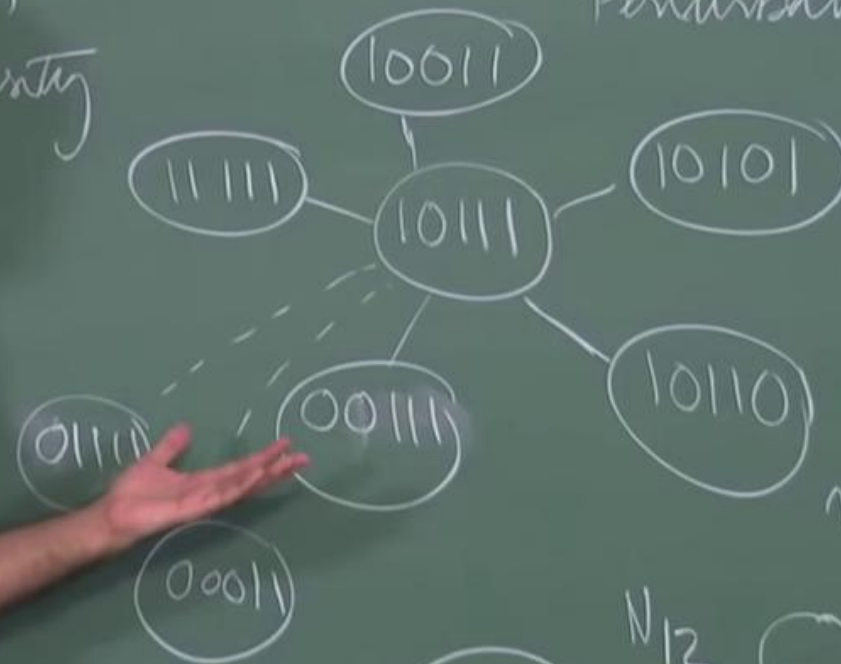
```
graph TD; A((10111)) --- B((11111)); A --- C((10011)); A --- D((00111)); C --- E((01111)); C --- F((00011)); F --- G((00001)); E -.- G; H((~ N12345))
```


Local Search \rightarrow local maxima

Solution Space Search

Perturbation

high density



N_1 - change

N_2 - change

N_{12}

N_{123}

\vdots

$N_{1..n}$

more dense neighbourhood

N_3

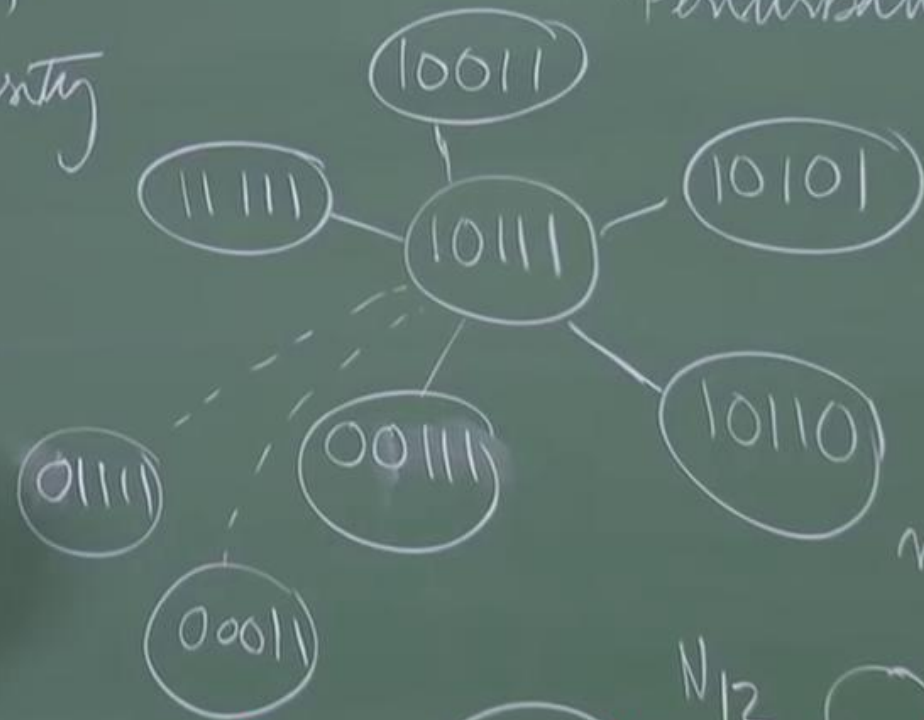
\vdots

N_n

Local Search \rightarrow local maxima

Solution Space Search
Perturbation

(N_1, N_2, \dots)
increasing density



"An optimization problem may have more than one solution"

Solution Space Search

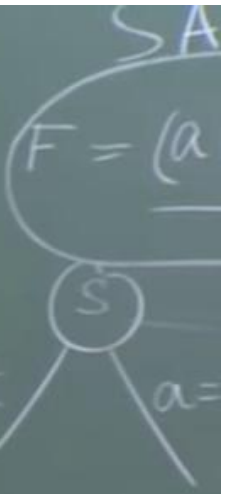
$$\text{var} = \{a, b, c, d, e\}$$

n variables

$$- 2^n \text{ states}$$

$$n = 100?$$

$$2^{100} \approx 10^{30} \text{ states}$$



6-Queen

(6, 1, 3, 4, ...)



N_1 - change 1 bit

N_2 - change any 2 bits

more dense neighbourhood
 N_3
 N_4
 N_5

Local search \rightarrow local maxima

Solution Space Search

Perturbation

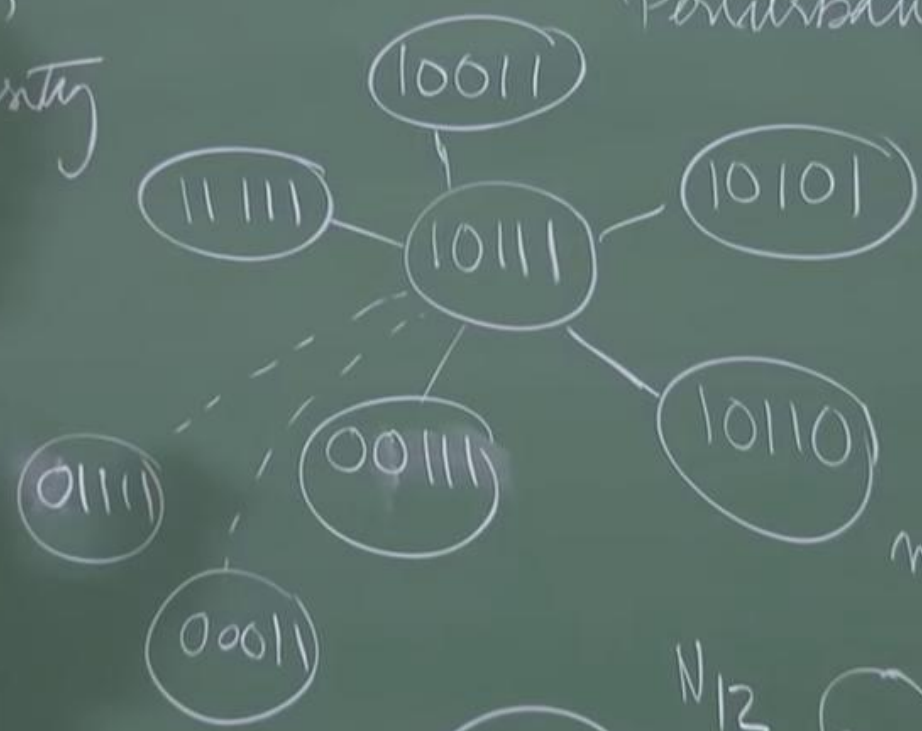
var = $\{$

n varca

n = 100

2

very density



N_1 - change 1

N_2 - change an

n_2

N_{12}

N_{123}

N_{1234}

N_{12345}

more dense neighbourhood

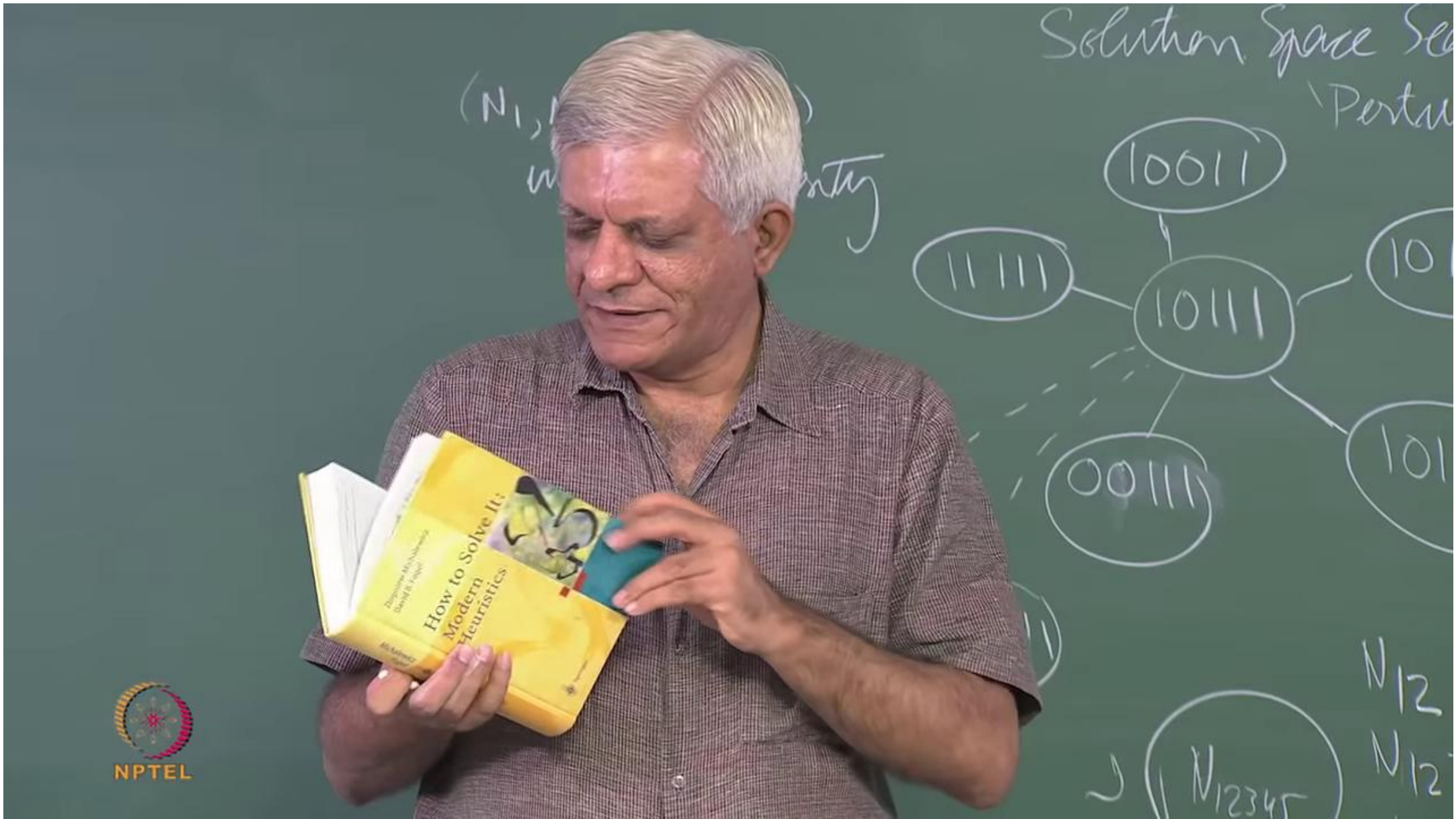
N_3

N_4

N_n



NPTEL



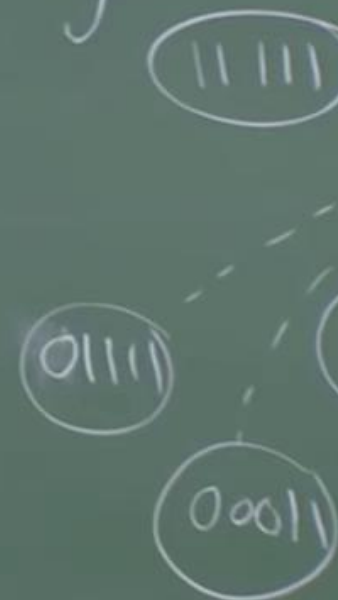
SEARCH WINDY
Speech Recognition
beam width = 2



costs a
costs a

(N_1, N_2, \dots)
increasing density

$i=1$
 \downarrow
 $HC(n_i)$
 $i \leftarrow i+1$



increasing values

$$i = 1$$

$$HC(n_i)$$
$$i \leftarrow i + 1$$

Local search \rightarrow local minima

Solution Space Search

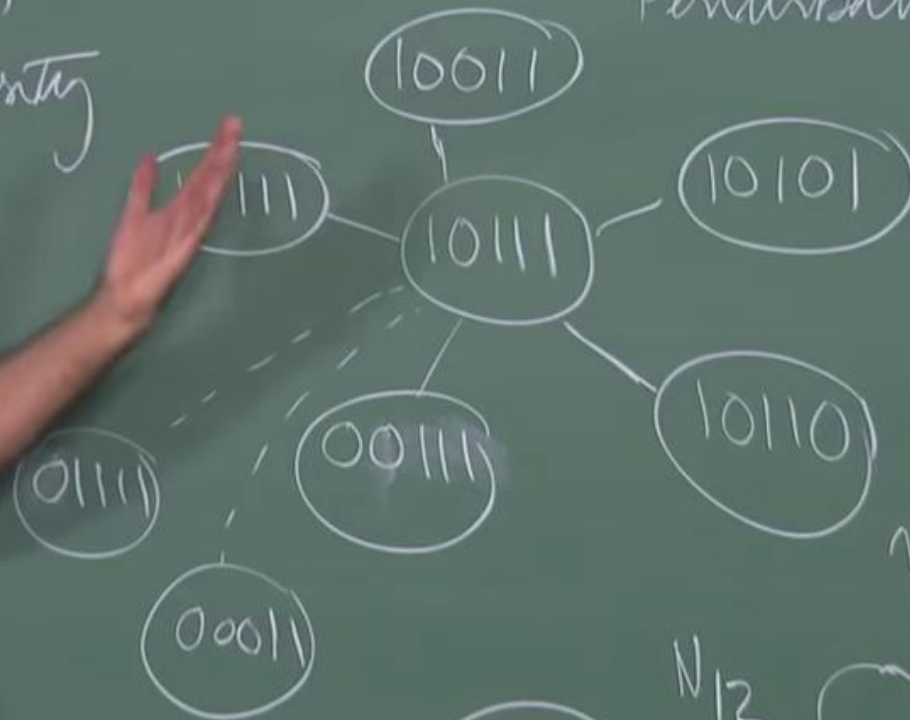
Perturbation

(N_1, N_2, \dots)
increasing density

var =

n var

n =



N_1 - change
 N_2 - change

N_{12}
 N_{123}
 N_{12345}
 $N_{1 \dots n}$
 N_3
 N_n
more dense neighbourhood

VARIABLE

NEIGHBOURHOOD

DESCENT

1-1



NPTEL

BEAM SEARCH VITERBI
Speech Recognition



beam

VARIABLE
NEIGHBOURHOOD (N_1, N_2, \dots)
DESCENT $l=1$
(VDN) increasing density

$HC(m_i)$
 $i \leftarrow i+1$

01111

Speech Recognition

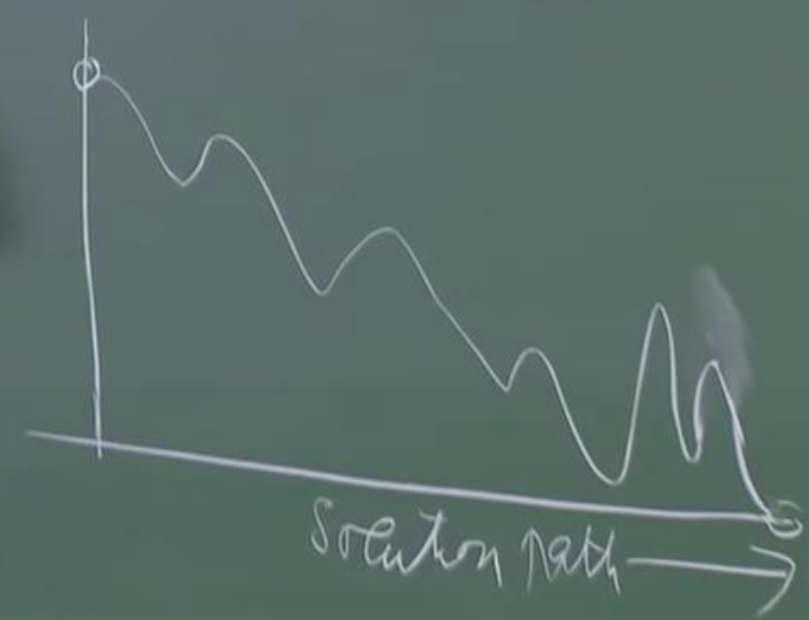


beam = 2

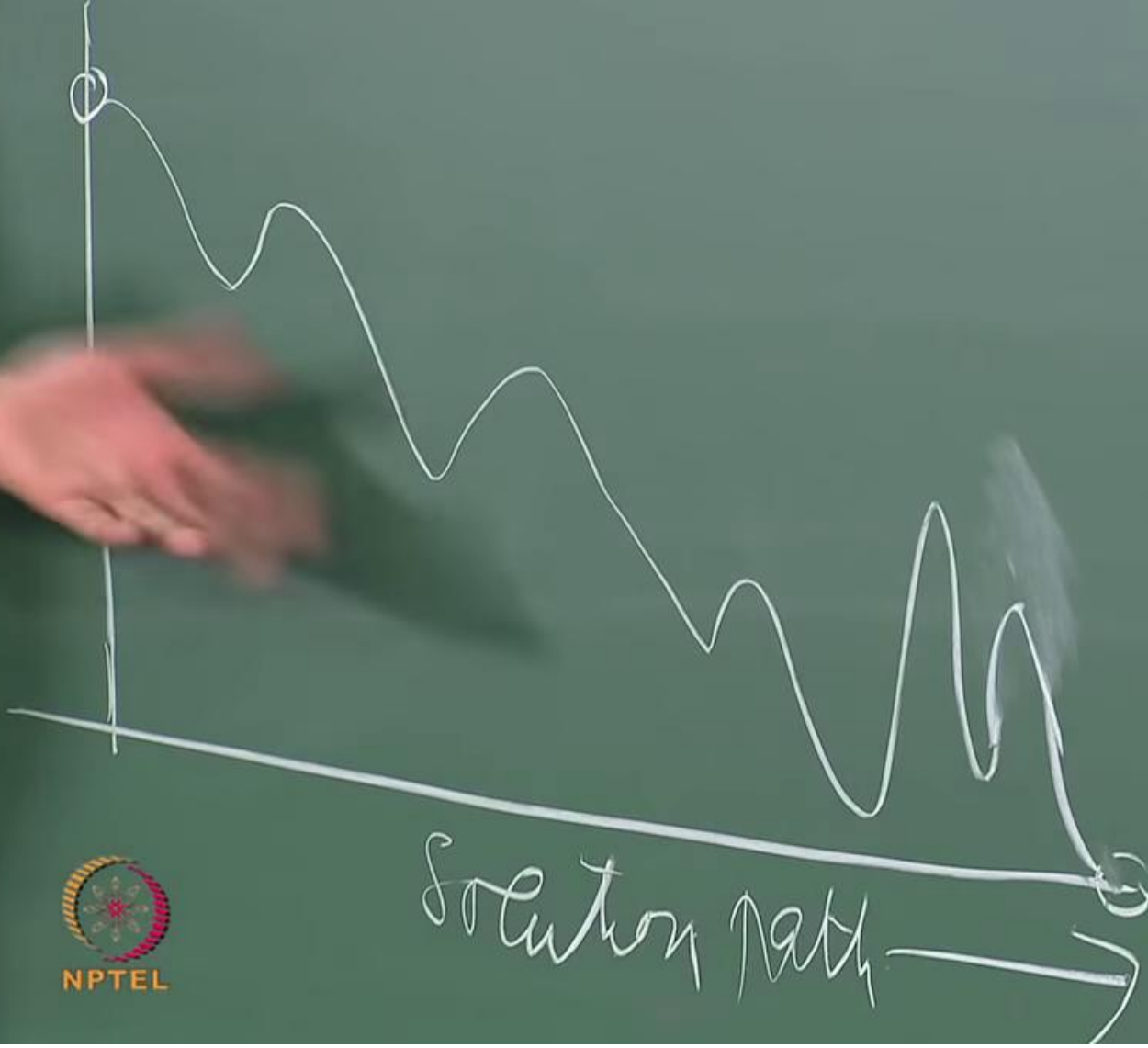
egg
in a leg

VARIABLE
NEIGHBOURHOOD (N_1, N_2, \dots)
DESCENT $l=1$ increasing
(VDN)

$HC(n_i)$
 $i \leftarrow i+1$



01111



01111

