INF 311

Introduction to computer science

Lecture 10: Introduction to algorithms

Exhaustive & greedy search algorithms
Dynamic programming

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Examen final 2008

Lundi **7 Juillet** de 9h a 11h

- Note finale (HC): 1/3 Pale machine + **2/3** Pale papier
- Le polycopie INF311+transparents sont autorises
- Sujet en Francais *or in English* (FR/EN)
- Les EV2s ont le droit a 30 minutes supplementaires
- Plusieurs parties independantes

Examen final 2008

- (re?)Lire le polycopie:
  Chapitres 1 a 11 (130 pages)
- Regarder les annales

INF 311: Introduction à l'informatique, niveau débutant

LSEN
Mise à jour, Lundi 16 Juin 2008.

ur entrée à l'Ecole aux élèves ayant peu ou pas de connaissances en informatique.

Le poly est disponible en pdf

Les pages des travaux dirigés

La pale de juillet 2006 et son corrigé .

http://www.enseignement.polytechnique.fr/informatique/INF311/

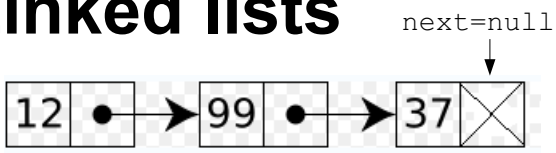
Agenda

A few algorithms and paradigms:

- I/ **Exhaustive search**
- II/ **Greedy algorithm** (set cover problems)
- III/ **Dynamic programming** (knapsack)

+...*Merging two lists*...

Linked lists




```
public class List
{
int container;
List next;  // a reference to a cell of a list

// Constructor  List(head, tail)
// Build a cell so that
//         the reference to the next cell is the tail
List(int element, List tail)
   {
   this.container=element;
   this.next=tail;
   }

}
```

Merging ordered linked lists

- Two *linked lists* `u` and `v` of increasing integers
- Build a *new linked list* in increasing order...
- ...using **only cells** of `u` and `v` (no cell creation, `new`)

For example:

U	3-->6-->8-->null
V	2-->4-->5-->7-->9-->null
Merge(U,V)	2-->3-->4-->5-->6-->7-->8-->9-->null

Linked lists

```
class List
{
int container;
List next;

// Constructor  List(head, tail)
List(int element, List tail)
    {
    this.container=element;
    this.next=tail;
    }

List insert(int el)   // insert element at the head of the list
{
return new List(el,this);
}

void Display()
{
List u=this;

while(u!=null)
    {
    System.out.print(u.container+"-->");
    u=u.next;
    }
System.out.println("null");
}

}
```

U	3-->6-->8-->null
V	2-->4-->5-->7-->9-->null

```
class MergeList
{
//
// Merge two ordered lists
//
static List mergeRec(List u, List v)
{
if (u==null) return v;
if (v==null) return u;

if (u.container < v.container)
    {
    // Recycle cells/ no new
    u.next=mergeRec(u.next,v);
    return u;
    }
else
    {
    // Recycle cells/no new
    v.next=mergeRec(u,v.next);
    return v;
    }

}
```

```
public static void main(String [] args)
{
List u=new List(8,null);
u=u.insert(6);u=u.insert(3);
u.Display();

List v=new List(9,null);
v=v.insert(7);v=v.insert(5);
v=v.insert(4);v=v.insert(2);
v.Display();

List w=mergeRec(u,v);
w.Display();
}
```

```
static List sortRec(List u)
{
int i,l=u.length(), lr;
List l1, l2, split, psplit; // references to cells

if (l<=1)
   return u;
else
   {
   l1=u;

   psplit=split=u;
   i=0;lr=l/2;


   while (i<lr)
      {i++;
      psplit=split;
      split=split.next;}

   l2=split; // terminates with a null
   psplit.next=null;

   return mergeRec( sortRec(l1), sortRec(l2) );
   }
}
```

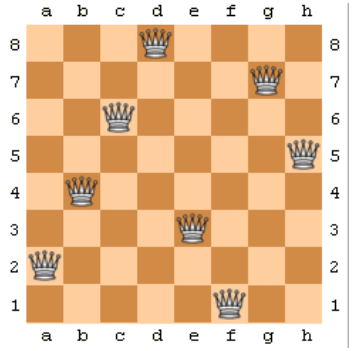
Sort in O(n log n) time:
- Split list in two halves
- Recursively apply sorting
- Merge ordered lists

```
public static void main(String [] args)
{

List u=new List(3,null);
u=u.insert(2);
u=u.insert(9);
u=u.insert(6);u=u.insert(1);
u=u.insert(15);u=u.insert(17);
u=u.insert(23);u=u.insert(21);
u=u.insert(19);u=u.insert(20);

u.Display();

List sortu=sortRec(u);
System.out.println("Sorted linked list:");
sortu.Display();
}
```

20-->19-->21-->23-->17-->15-->1-->6-->9-->2-->3-->null
Sorted linked list:
1-->2-->3-->6-->9-->15-->17-->19-->20-->21-->23-->null

Exhaustive search (Brute force search)

The Eight Queens puzzle:



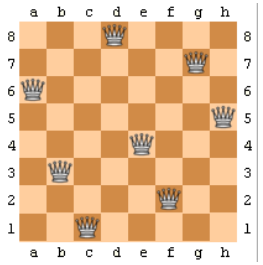
Max Bezzel (1848, chess player)
Find safe positions of 8 queens on a 8x8 chessboard

- 92 distinct solutions
- 12 non-naive distinct solutions (rotation/symmetry)
- Good exercise for *designing* algorithms
- Generalize to n-queens

Exhaustive search & Backtracking

Brute force (naive) algorithm:
Check all *64x63x...x57/8! = 283,274,583,552* ?! solutions...

Easy to check that a **configuration** is not safe
(*check horizontal/vertical/diagonal lines*)



→ Two queens cannot be on the same line...

Therefore, *incrementally place queen* i (0...7)
on the i-th row, on the first **free** column

If there is no more free columns left, then **backtrack**...

Exhaustive search & Backtracking

Incrementally place queen i (0...7) on the first **free** column
If there is no more free columns left, then **backtrack:**

Consider the previous queen position and increment its column position, etc., etc., etc.

... until we find a solution
(=reach a successful location for queen indexed 7)

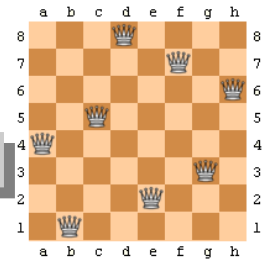
`queen`: 1D Array that specifies the column position
Queen i is located at position `(i,queen[i])`
(with i ranging from 0 to 7)

`search`: Static function that returns a/all solution(s).

```
// Are queen (i1,j1) and queen (i2,j2) safe ?
static boolean WrongPos(int i1, int j1, int i2, int j2)
{ // same row?, same col?, same diag?
return (i1==i2 ||
      j1==j2 ||
      Math.abs(i1-i2) == Math.abs(j1-j2));
}

// Place safely queen i at column j?
static boolean FreeMove(int i, int j)
{
boolean result=true;

for(int k=0;k<i;k++)
   result=result&&!WrongPos(i,j,k,queen[k]);

return result;
}
```

Check for the queens placed so far on the chessboard

Static functions to check for collisions




```
static boolean search(int row)
{
boolean result=false;

if (row==n)
   {// Terminal case
    DisplayChessboard();
    nbsol++;
   }
   else
   {// Exhaustive search
   int j=0;

      while(!result && j<n)
      {
         if (FreeMove(row,j))
         {
            queen[row]=j;
            result=search(row+1); // RECURSION/BACKTRACK
         }
         j++; // explore all columns
      }
    }
   return result;
}
```

Increment the number of found solutions (static class variable)

```
static final int n=8;
static int [] queen=new int[n];
static int nbsol;

static void DisplayChessboard()
{
int i,j;

System.out.println("");

for(i=0;i<n;i++)
   {
      for(j=0;j<n;j++)
      {
         if (queen[i]!=j) System.out.print("0");
            else System.out.print("1");
      }
      System.out.println("");
   }
}
```

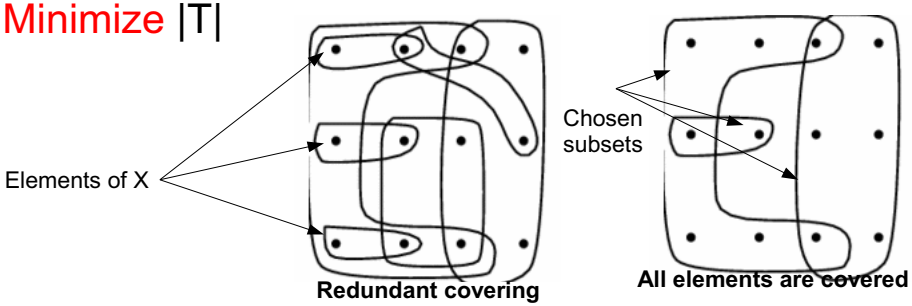
```
00100000
10000000
00000010
00010000
00000100

00000001
00100000
10000000
00000100
01000000
00001000
00000010
00010000

00000001
00010000
10000000
00100000
00000100
01000000
00000010
00001000
Total number of solution:92
```

```
public static void main(String [] arguments)
{
nbsol=0;
search(0); // Call exhaustive search procedure
System.out.println("Total number of solutions:"+nbsol);
}
```

Optimization: Set Cover Problem (SCP)

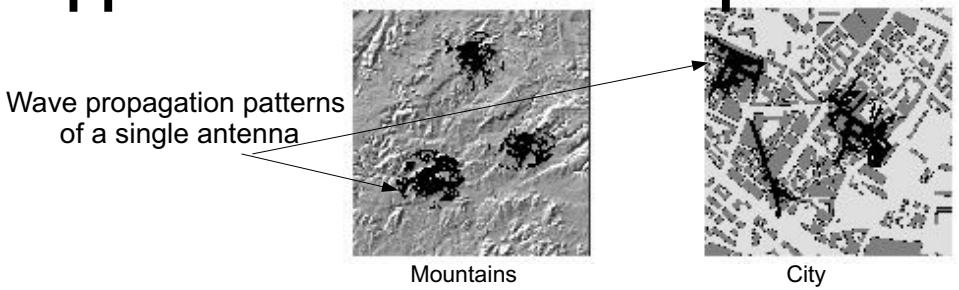
- Given a graph:
  - A **finite set** X = {1, …, n}
  - A **collection of subsets** of S: S_1, S_2, …, S_m

- **Problem**:
  - Find a subset T of {1, …, m} such that $U_{j \text{ in } T} S_j = X$
  - Minimize |T|



http://www.cs.sunysb.edu/~algorith/files/set-cover.shtml

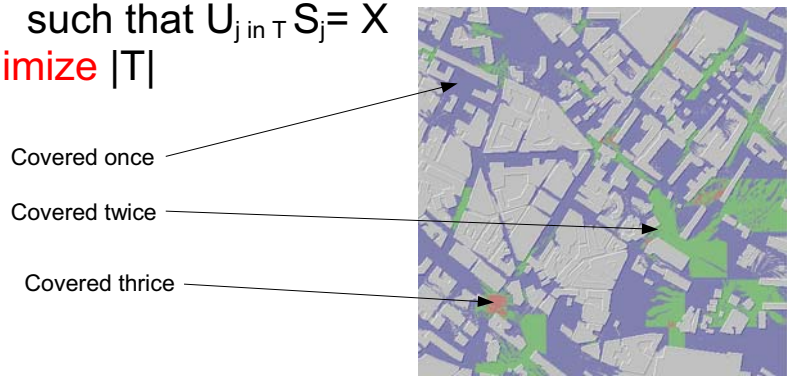
Applications of set cover problems



- Choose base stations for quality of service (cell phone network, etc)
- Discretize terrain using a regular grid (set X)
- Each position of antenna -> subset of covered grid areas (S)
- Minimize the number of chosen antennas (X)

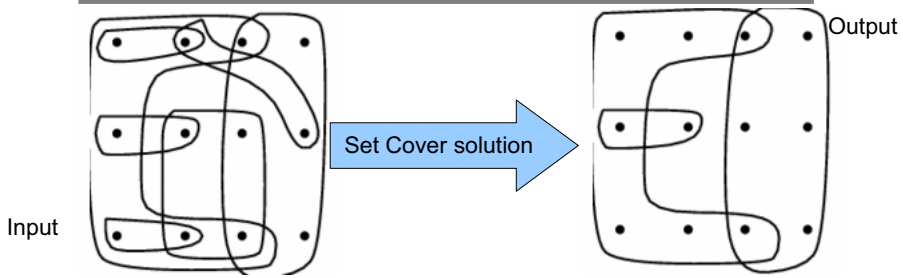
- Given a graph:
  - A **finite set** X = {1, …, n} (=regular grid elements)
  - A **collection of subsets** of S (=antenna patterns)
    S_1, S_2, …, S_m

- **Problem**:
  - Find a subset T of {1, …, m} (=subset of antennas) such that $U_{j \text{ in } T} S_j = X$
  - Minimize |T|



A greedy algorithm (algorithme glouton)

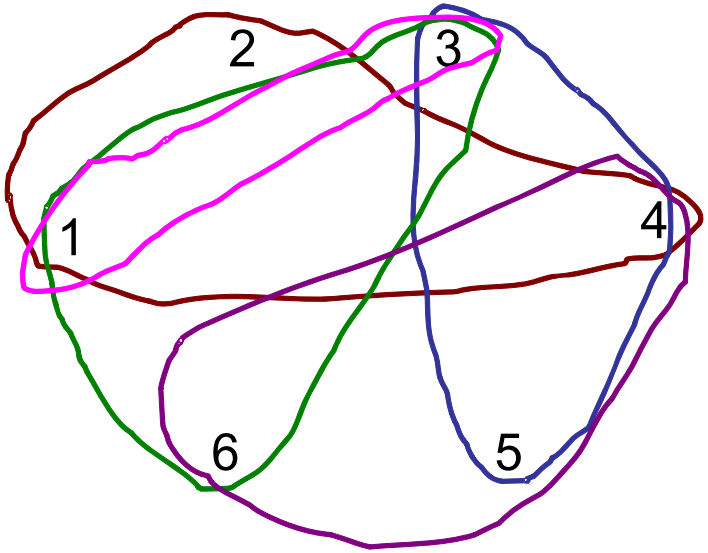
```
GREEDY-SET-COVER(X,S)
1 M ← X     // all elements must be covered
2 C ← Ø     //  chosen subsets
3 while M ≠ Ø do
4       select an Q ∈ S that maximizes |Q ∩ M|
5          M ← M – Q
6          C ← C U {Q}
7 return C
```



Visualizing a « range set »

Elements:
X = {1, …, 6}

Subsets:
S_1 = {1,2,4}
S_2 = {3,4,5}
S_3 = {1,3,6}
S_4 = {2,3,5}
S_5 = {4,5,6}
S_6 = {1,3}



Data-structure for the set cover problem

X = {1, …, 6}

S_1 = {1,2,4}
S_2 = {3,4,5}
S_3 = {1,3,6}
S_4 = {2,3,5}
S_5 = {4,5,6}
S_6 = {1,3}

M=6 SUBSETS

1	2	3	4	5	6	
1	1	0	1	0	0	S_1
0	0	1	1	1	0	S_2
1	0	1	0	0	1	S_3
0	1	1	0	1	0	S_4
0	0	0	1	1	1	S_5
1	0	1	0	0	0	S_6

N=6 ELEMENTS

Incidence matrix: boolean matrix

```
class SetCover
{
int nbelements;
int nbsubsets;
boolean [][] incidenceMatrix;

//Constructor
SetCover(int nn, int mm)
{
this.nbelements=nn; this.nbsubsets=mm;

incidenceMatrix=new boolean[nbsubsets][nbelements];

for(int i=0;i<nbsubsets;i++)
   for(int j=0;j<nbelements;j++)
      incidenceMatrix[i][j]=false;
}

void SetSubsets(int [] [] array) // Set incidence matrix
{for(int j=0;j<array.length;j++)
   {for(int i=0;i<array[j].length;i++)
         incidenceMatrix[j][array[j][i]]=true;
   }
}

}
```

```
void Display()
{
for(int i=0;i<nbsubsets;i++){

   for(int j=0;j<nbelements;j++)
      if (incidenceMatrix[i][j]) System.out.print("1");
         else System.out.print("0");
         System.out.println("");
         }
}
```

```
public static void main(String [] args)
{
int [][] subsets={{0,1,3},{2,3,4}, {0,2,5},{1,2,4},{3,4,5},{0,2}};

SetCover setcover=new SetCover(6,6);
setcover.SetSubsets(subsets);

System.out.println("Set cover problem:");
setcover.Display();
}
```

```
Set cover problem:
110100
001110
101001
011010
000111
101000
```

Greedy algorithm

```
static boolean [] GreedySCP(SetCover problem)
{
boolean [] result=new boolean[problem.nbsubsets];
int cover=0; int select;

for(int i=0;i<problem.nbsubsets;i++)  // initially no subsets
      result[i]=false;

while(cover!=problem.nbelements)
{
// Choose largest not-yet covered subset
select=problem.LargestSubset();
result[select]=true;

// Update covered matrix
cover+=problem.Cover(select);

// Update incidence matrix
problem.Update(select);

System.out.println("Selected "+select+" Number of covered
elements="+cover);
problem.Display();
}

return result;
}
```

Methods of class SetCover

```
// Number of covered element by subset i
int Cover(int i)
{
int nbEl=0;

for(int j=0;j<nbelements;j++)
      if (incidenceMatrix[i][j]) ++nbEl;

return nbEl;
}

// Report the current largest subset
int LargestSubset()
{
int i, nbel, max, select;

max=-1;select=-1;

for(i=0;i<nbsubsets;i++)
   {
   nbel=Cover(i);
   if (nbel>max) {max=nbel; select=i;}
   }

return select;
}
```

Methods of class SetCover

```
// Update the incidence matrix
void Update(int sel)
{
int i,j;

for(i=0;i<nbsubsets;i++)
{
  if (i!=sel) //use sel below so don't modify it
     {
     for(j=0;j<nbelements;j++)
        if (incidenceMatrix[sel][j])
           incidenceMatrix[i][j]=false;
     }
}
// Remove the chosen subset as well
for(j=0;j<nbelements;j++)
     incidenceMatrix[sel][j]=false;
}
```

```
public static void main(String [] args)
{
int [] [] subsets ={{0,1,3},{2,3,4},
                    {0,2,5},{1,2,4},
                    {3,4,5},{0,2}};
SetCover setcover=new SetCover(6,6);

setcover.SetSubsets(subsets);

System.out.println("Set cover problem:");
setcover.Display();

boolean [] solution=GreedySCP(setcover);

System.out.print("Solution:");
for(int i=0;i<setcover.nbsubsets;i++)
if (solution[i]) System.out.print(" "+i);
System.out.println("");
}
```

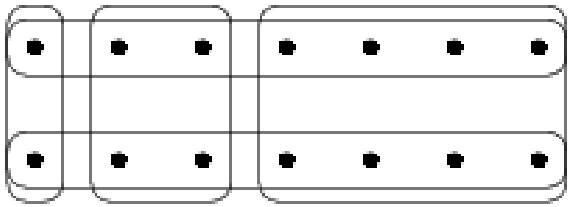
```
Set cover problem:
110100
001110
101001
011010
000111
101000
Selected 0 Number of covered elements=3
000000
001010
001001
001010
000011
001000
Selected 1 Number of covered elements=5
000000
000000
000001
000000
000001
000000
Selected 2 Number of covered elements=6
000000
000000
000000
000000
000000
000000
Solution: 0 1 2
```

Optimization bounds for greedy algorithm

CoptT<= Cgreedy <= ApproximationFactor x Copt

Upper bound:
Approximation factor is at most H(n)<=log(n)

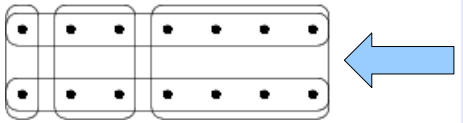
2 sets is optimal solution
but greedy chooses 3 sets here

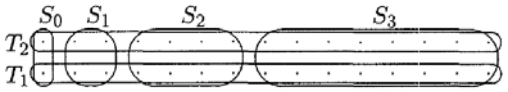


Lower bound:
Approximation factor can be as big as Omega(log(n))

Difficult to approximate: cannot beat (1-eps)Opt unless P=NP

```
int [] [] subsets={{0,1,2,3,4,5,6},{7,8,9,10,11,12,13},
                   {0,7},{1,2,8,9},{3,4,5,6,10,11,12,13}};
   SetCover setcover=new SetCover(14,5);
```





Etc...

Easy to build generic examples
where greedy does not behave well
with O(log n) approximation ratio

```
Set cover problem:
11111110000000
00000001111111
10000001000000
01100000110000
00011110001111
Selected 4 Number of covered elements=8
11100000000000
00000001110000
10000001000000
01100000110000
00000000000000
Selected 3 Number of covered elements=12
10000000000000
00000001000000
10000001000000
00000000000000
00000000000000
Selected 2 Number of covered elements=14
00000000000000
00000000000000
00000000000000
00000000000000
00000000000000
Solution: 2 3 4
```

Knapsack problem (sac a dos)

(First version)

Given:

- A set of n Objects `O1, ..., On` with
  corresponding weights `W1, ..., Wn`
- And a bag (knapsack) of capacity `W`

Find:

All the ways of choosing objects to **fully** fill the bag

Filling the knapsack

Need to enumerate all possibilities:
n objects => 2^n choices
(2, 4, 8, 16, 32, 64, ...)

How to program this?
n **is** a variable
(cannot fix the number of nest loops)

Need to enumerate all combinations:

= **Exhaustive search**

```
n=4
2^4=16

1 1 1 1
1 1 1 0
1 1 0 1
1 1 0 0
1 0 1 1
1 0 1 0
1 0 0 1
1 0 0 0
0 1 1 1
0 1 1 0
0 1 0 1
0 1 0 0
0 0 1 1
0 0 1 0
0 0 0 1
0 0 0 0
```

Enumerating: A recursive approach

```
static void Display(boolean [] tab)
{
for(int i=0;i<tab.length;i++)
   if (tab[i]) System.out.print("1 ");
      else
      System.out.print("0 ");

System.out.println("");
}

static void Enumerate(boolean [] selection, int pos)
{
if (pos==selection.length-1)
      Display(selection);
   else
   {
   pos++;
   selection[pos]=true;
   Enumerate(selection,pos);
   selection[pos]=false;
   Enumerate(selection,pos);
   }
}
```

```
public static void main(String[] args)
{
int n=4;
int i;
boolean [] select=new boolean[n];
for(i=0;i<n;i++)
   select[i]=false;

Enumerate(select,-1);
}
```

Fully filling the knapsack

```
final static int n=10; // 10 objects
static int [] weight={2,3,5,7,9,11,4,13,23,27};

static void SolveKnapSack(boolean [] chosen, int goal, int
i, int total)
{
numbercall++; // keep track of total number of calls

if ((i>=chosen.length)&&(total!=goal)) return;

if (total==goal)
   {  Display(chosen, goal);
         numbersol++; // total number of solutions
      }
else
   {
   chosen[i]=true;// add item first
   SolveKnapSack(chosen,goal,i+1,total+weight[i]);
   chosen[i]=false;  // and then remove it
   SolveKnapSack(chosen,goal,i+1,total);
   }
}
```

```
final static int n=10; // 10 objects
static int [] weight={2,3,5,7,9,11,4,13,23,27};

public static void main(String [] args)
{
int totalweight=51;
numbersol=0;
numbercall=0;

System.out.println("Knapsack:");
boolean [] chosen=new boolean[n];

SolveKnapSack(chosen, totalweight, 0, 0);
System.out.println("Total number of
 solutions:"+numbersol);
System.out.println(" #calls="+numbercall);
}
```

```
Knapsack:
2+3+5+7+11+23+0=51
2+5+7+9+11+4+13+0=51
2+5+4+13+27+0=51
2+7+11+4+27+0=51
2+9+4+13+23+0=51
2+9+13+27+0=51
3+5+7+9+4+23+0=51
3+5+7+9+27+0=51
3+5+7+13+23+0=51
3+5+9+11+23+0=51
7+4+13+27+0=51
9+11+4+27+0=51
11+4+13+23+0=51
11+13+27+0=51
Total number of solutions:14
 #calls=2029
```

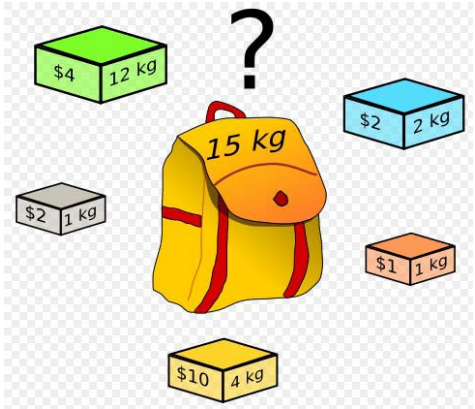
Exhaustive search: Branch & bound

```
static void SolveKnapSack(boolean [] chosen, int goal, int i,
int total)
{
numbercall++;

if (total>goal) return; // cut

if ((i>=chosen.length)&&(total!=goal)) return;

if (total==goal)
   {  Display(chosen, goal);
         numbersol++;
      }
else
   {
   chosen[i]=true;// add item first
   SolveKnapSack(chosen,goal,i+1,total+weight[i]);
   chosen[i]=false;  // and then remove it
   SolveKnapSack(chosen,goal,i+1,total);
   }

}
```

Stop recursion if we already exceed the weight amount

```
Knapsack:
2+3+5+7+11+23+0=51
2+5+7+9+11+4+13+0=51
2+5+4+13+27+0=51
2+7+11+4+27+0=51
2+9+4+13+23+0=51
2+9+13+27+0=51
3+5+7+9+4+23+0=51
3+5+7+9+27+0=51
3+5+7+13+23+0=51
3+5+9+11+23+0=51
7+4+13+27+0=51
9+11+4+27+0=51
11+4+13+23+0=51
11+13+27+0=51
Total number of solutions:14 #calls=1791
```

Knapsack: Fundamental optimization problem



Given a bag capacity (15 kg),
maximize the **utility** (price) of selected objects

(NP-hard problem)

Knapsack optimization problem

Given $p_1, p_2, \ldots p_n$ ← weights

$a_1, a_2, \ldots, a_n$ ← utility

$Pmax$ ← Maximum weight (capacity of bag)

Optimize $\sum_{i \in I} \; a_i$

such that

$$\sum_{i \in I} p_i \;\leq\; Pmax$$

(Maybe there exists several solutions)

Knapsack: Example

$Pmax$ = 12 8 objects

weight	2	3	5	2	4	6	3	1
utility	5	8	14	6	13	17	10	4

Dynamic programming (Knapsack)

Dynamic programming computes a table...
... from which a solution can be retrieved.

Requires a relational equation to deduce solutions progressively.

Dynamic programming (Knapsack)

Let u(i,j) be the maximum utility by
taking objects in {1, ...,i} with total weight <=j

- If i=1 then u(i,j)=0 for j<p1
  and u(i,j)=A1 for j>=P1
- If i>1
  u(i,j)=max(u(i-1,j) , u(i-1,j-Pi)+Ai)

Do not take object Oi

Take object Oi:
- gain Ai
- but leave room: Pi

weight	2	3	5	2	4	6	3	1
utility	5	8	14	6	13	17	10	4

Pmax= 12

u(i,j)=max(u(i-1,j) , u(i-1,j-Pi)+Ai)

$u_{i,j}$	0	1	2	3	4	5	6	7	8	9	10	11	12
$i=1$	0	0	5	5	5	5	5	5	5	5	5	5	5
$i=2$	0	0	5	8	8	13	13	13	13	13	13	13	13
$i=3$	0	0	5	8	8	14	14	19	22	22	27	27	27
$i=4$	0	0	6	8	11	14	14	20	22	25	28	28	33
$i=5$	0	0	6	8	13	14	19	21	24	27	28	33	35
$i=6$	0	0	6	8	13	14	19	21	24	27	30	33	36
$i=7$	0	0	6	10	13	16	19	23	24	29	31	34	37
$i=8$	0	4	6	10	14	17	20	23	27	29	33	35	38

Optimization result: Maximum utility, given Pmax

Reading *back:* Solution

2	3	5	2	4	6	3	1
5	8	14	6	13	17	10	4

$u_{i,j}$	0	1	2	3	4	5	6	7	8	9	10	11	12	
$i=1$	0	0	5	5	5	5	5	5	5	5	5	5	5	Choose (38=33+5, 2-2=0)
$i=2$	0	0	5	8	8	13	13	13	13	13	13	13	13	5=5 do not choose
$i=3$	0	0	5	8	8	14	14	19	22	22	27	27	27	5=5 do not choose
$i=4$	0	0	6	8	11	14	14	20	22	25	28	28	33	Choose (33=27+6,4-2=2)
$i=5$	0	0	6	8	13	14	19	21	24	27	28	33	35	Choose (27=14+13,8-4=4)
$i=6$	0	0	6	8	13	14	19	21	24	27	30	33	36	24=24, do not choose
$i=7$	0	0	6	10	13	16	19	23	24	29	31	34	37	Choose (14, 11-3=8)
$i=8$	0	4	6	10	14	17	20	23	27	29	33	35	38	Choose (4, 11)

Choose (Utility=0, Pmax=12)

From the table, chosen solution: O8, O7, O5, O4, O1

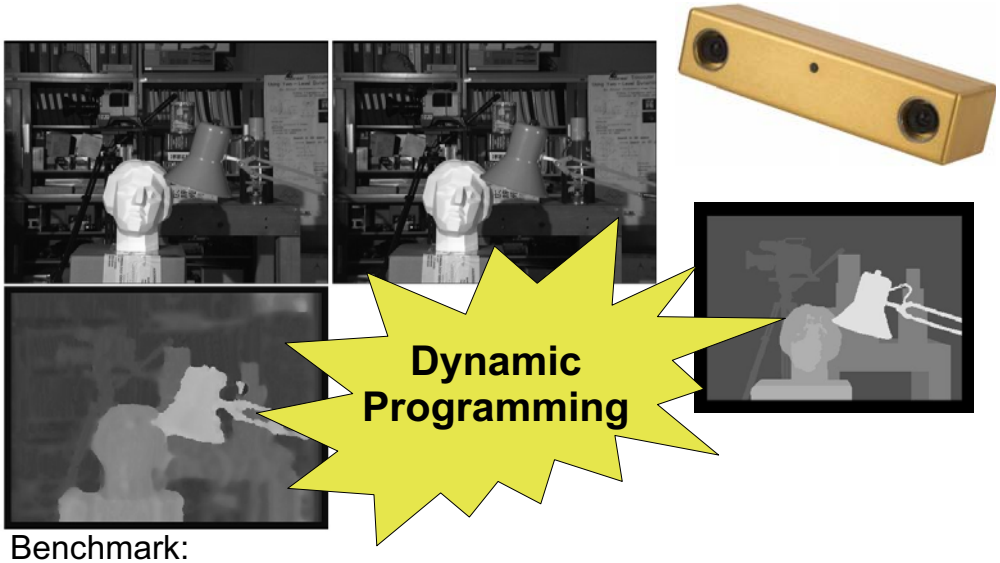
```
static int nbObjects=8;
static int [] weight={2,3,5,2,4,6,3,1};
static int [] utility={5,8,14,6,13,17,10,4};
static int weightmax=12;
static int [] [] array;

static void SolveDP()
{
int i,j;
array=new int[nbObjects][weightmax+1];

// initialize the first row
for(j=0;j<=weightmax;j++)
   if (j<weight[0]) array[0][j]=0;
         else array[0][j]=utility[0];
// for all other rows
for(i=1;i<nbObjects;i++)
   {
   for(j=0;j<=weightmax;j++)
      if (j-weight[i]<0) array[i][j]=array[i-1][j];
       else
         array[i][j]=max( array[i-1][j],
                     array[i-1][j-weight[i]]+utility[i]);
   }
}
```

```
static void InterpretArray()
{
int i,u,w;
u=0;
w=weightmax;

for(i=nbObjects-1;i>=1;i--)
{
   if (array[i][w]!=array[i-1][w])
         {System.out.print((i+1)+" ");
         w=w-weight[i];
         u=u+utility[i];
         }
}

if (array[0][w]!=0);
   {System.out.println("1");
   w=w-weight[0];
   u=u+utility[0];
   }
System.out.println("Cross check:"+u+" remaining weight "+w);
}
```

```
public static void main(String[] args)
{
System.out.println("Solving knapsack using the dynamic
            programming paradigm.");
SolveDP();
Display();
System.out.println("Reading solution:");
InterpretArray();
}
```

```
Solving knapsack using the dynamic programming paradigm.
0       0       5       5       5       5       5       5       5       5       5       5       5
0       0       5       8       8       13      13      13      13      13      13      13      13
0       0       5       8       8       14      14      19      22      22      27      27      27
0       0       6       8       11      14      14      20      22      25      28      28      33
0       0       6       8       13      14      19      21      24      27      28      33      35
0       0       6       8       13      14      19      21      24      27      30      33      36
0       0       6       10      13      16      19      23      24      29      31      34      37
0       4       6       10      14      17      20      23      27      29      33      35      38
Reading solution:
8 7 5 4 1
Cross check:38 remaining weight 0
```

Dynamic programming: binocular stereo matching



Benchmark:
http://vision.middlebury.edu/~schar/stereo/web/results.php

Optimization: A brief summary

- Exhaustive search: recursion but O(2^n) complexity
- Can be improved by backtracking (cuts)
- Greedy algorithm: Polynomial O(n^3)
- but yields an approximation
- Dynamic programming yields an exact solution
  but requires O(weightxobjects) time
  (weights should not be too bigs)

Last but not least: Java applets!

Applets are special java programs...
...that can run into your favorite Internet browser

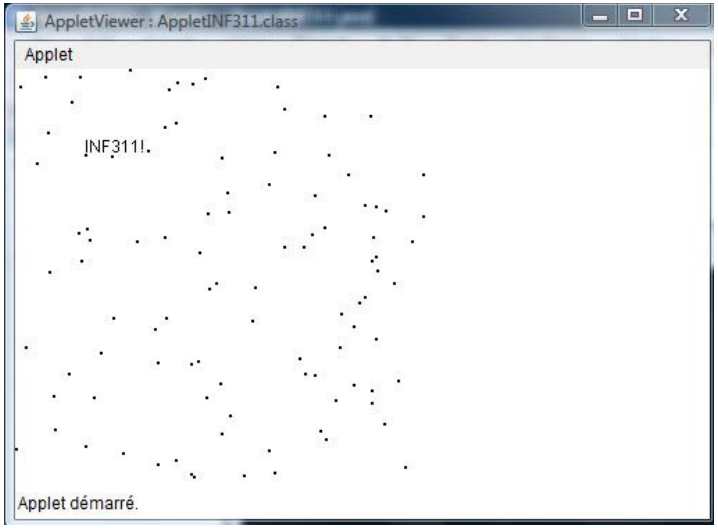
You need to:
(1) write a web page with `<APPLET> </APPLET>` tags
(2) write and compile the Java applet code (`javac`)

Advantages of applets are:
(1) to be accessible worldwide
(2) to provide graphics

```
import java.awt.*;
import java.applet.*;

class Point2D
{double x,y;
Point2D()
{this.x=300.0*Math.random();
this.y=300.0*Math.random();}}

public class AppletINF311 extends Applet {
final static int n=100;
static Point2D [] set;

    public void init() {
        int i;
        set=new Point2D[n];
        for(i=0;i<n;i++)
            set[i]=new Point2D();}

    public void paint(Graphics g) {int i;

        for(i=0;i<n;i++)
        {
        int xi, yi;
        xi=(int)set[i].x; yi=(int)set[i].y;
        g.drawRect(xi, yi,1,1);
        }
        g.drawString("INF311!", 50, 60 );
    }
}
```

Java applets

```
<APPLET
    code   = "AppletINF311.class"
    width  = "500"
    height = "300"
    >
</APPLET>
```



Java applets for online demos...

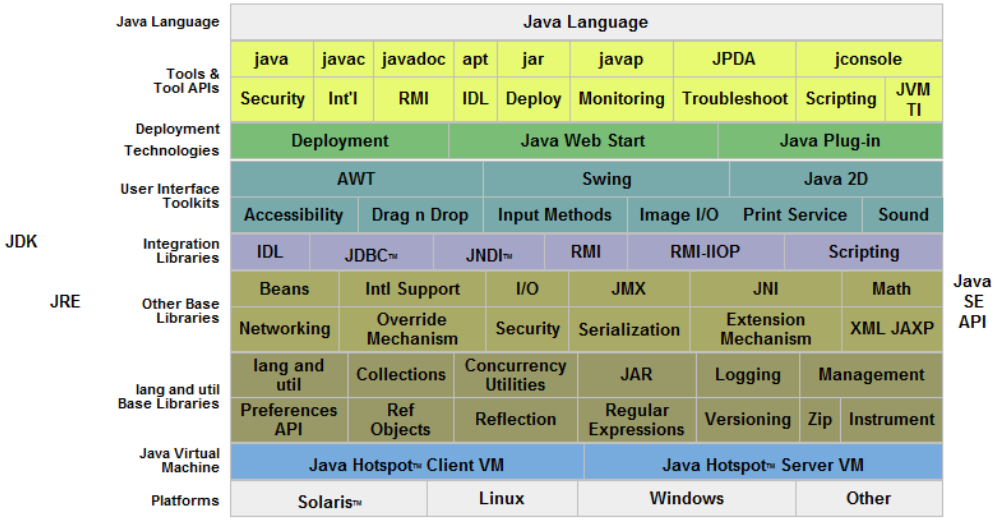
Hallucination (mirage)

Two technologies in use:
- Image segmentation
- Texture synthesis (hole filling)

Try it !!! http://www.sonycsl.co.jp/person/nielsen/ClickRemoval/

F. Nielsen, R. Nock ClickRemoval: interactive pinpoint image object removal. ACM Multimedia 2005

There is much more in Java!



JDK™ 6 Documentation

A glimpse at object inheritance

All objects inherit from the topmost object: `Object`
...meaning some methods are already **predefined**

java.lang
Class Object

`java.lang.Object`

`public class Object`

Class `Object` is the root of the class hierarchy. Every cl
the methods of this class.

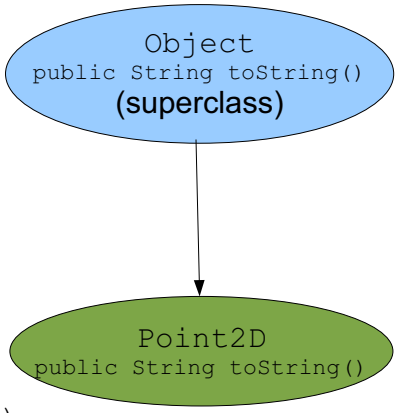
Method Summary

protected Object	`clone()` Creates and returns a copy of this object.
boolean	`equals(Object obj)` Indicates whether some other object is "equal to" this one.
protected void	`finalize()` Called by the garbage collector on an object when garbage collection determines that there are no more references to the object.
Class<?>	`getClass()` Returns the runtime class of this `Object`.
int	`hashCode()` Returns a hash code value for the object.
void	`notify()` Wakes up a single thread that is waiting on this object's monitor.
void	`notifyAll()` Wakes up all threads that are waiting on this object's monitor.
String	`toString()` Returns a string representation of the object.

Can overwrite the method `toString`

A glimpse at object inheritance

```
class Point2D
{double x,y;
// Constructor
Point2D(double xi, double yi)
{this.x=xi;this.y=yi; }
// Overrides default method
public String toString()
{return "["+x+" "+y+"]"; }
}

class SuperClass
{
public static void main(String [] a)
{
  Point2D myPoint=new Point2D(Math.PI, Math.E);
  System.out.println("Point:"+myPoint);
}
}
```




```
Point:[3.141592653589793 2.718281828459045]
```

http://www.enseignement.polytechnique.fr/profs/informatique/Robert.Cori/Questionnaire/resultatSondage.html

Sondage sur l'enseignement INF 311 (débutants), Promotion X2006: l résultats (mer jui 4 13:14:23 CEST 2007)

Nombre de réponses: 241

Les renseignements que vous fournirez dans ce sondage seront très utiles pour l'amélioration des enseignements futurs.

Qui êtes-vous?

- Votre nom (facultatif)
- Filière d'entrée à l'X MPI 2 MPSI 58 PC 112 PSI 36 PT 8 TSI 2 UNIV 2 EV1 3 EV2 22
- Votre numéro de groupe de TD 1 20 2 16 3 19 4 13 5 20 6 21 7 21 8 22 9 19 10 18 11 24 12 21

Opinions générales sur le cours

- Intérêt de la matière enseignée Grand 59 Assez grand 140 Assez faible 44 Faible 6
- Qualité globale de l'enseignement Grand 50 Assez grand 175 Assez faible 20 Faible 1

Please answer the poll INF311
(in TD10)

Inspired by Rober Cori...

Merci et a bientot!

Année	Septembre	Octobre	Novembre	Décembre	Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Août
1	Incorporation								INF 311: Introduction à l'informatique INF 321: Principes des langages de programmation			
2	INF 421: Programmation et Algorithmique		INF 421: Programmation et Algorithmique			INF 431: Algorithmes et Programmation: du séquentiel au distribué						
						INF444: Modex			INF444: Modex			
3		Programmes d'approfondissement (Master 1)							Stage de recherche (Master 1)			
4	Année professionalisante (Master 2)											

http://www.enseignement.polytechnique.fr/informatique/

- M1 Informatique, thematique Image
- Colloquium Nov. on visual computing.