Architectural Home Plan Design Supporting System with Knowledge Base Inspection

Interim Progress I

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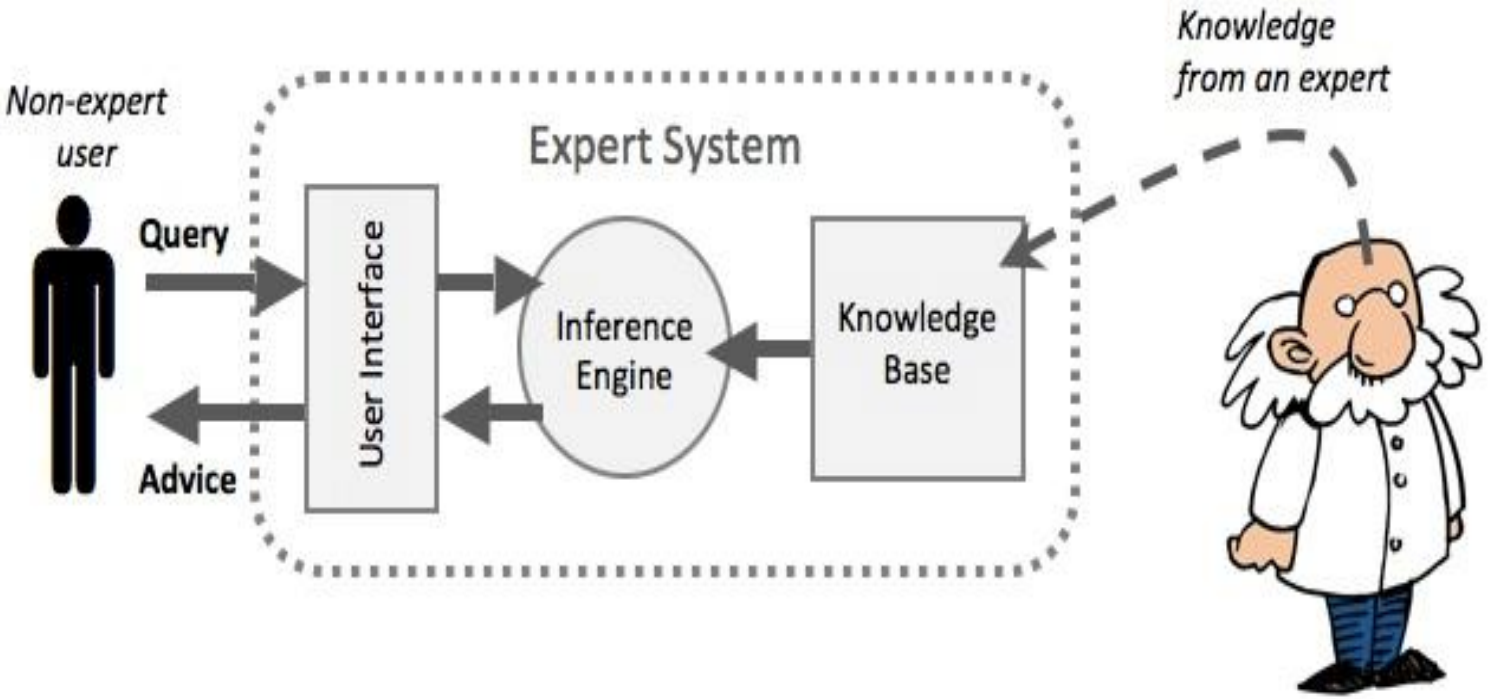
ICT/08/09/018
2298

Knowledge base paradigm



Organizing Knowledge → Representing Knowledge → Prototype Implementation

Knowledge Base Implementation Categories

- Geometrical Rules
- Architectural Rules
- Legal Rules

Knowledge Base Implementation First Phase

Geometrical Rules

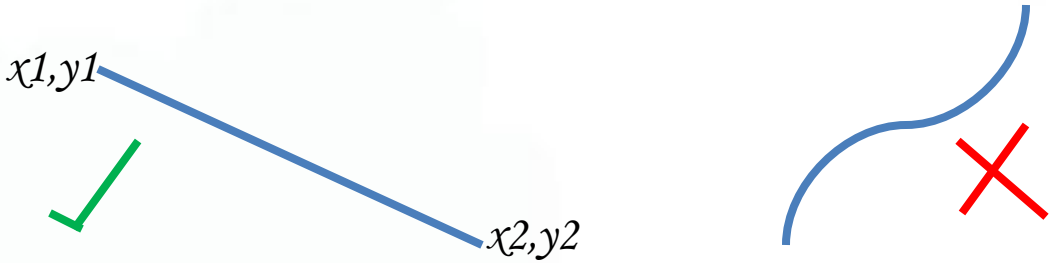
- Most difficult implementation
- Foundation of generating a design
- It is necessary to define the basic shape of a house

Outline of Geometrical Rule Knowledge Base Implementation

1. Define a Line
2. Define a Polygon
3. Find adjacency of two polygons
4. Find intersection of two polygons
5. Find overlapping of two polygons

Goal → Issues → Solutions

1. Define A Line




```
line([[X1,Y1],[X2,Y2]]) :- integer(X1), integer(X2), integer(Y1),  integer(Y2).
```

- Issue
  - ✓Generation of coordinates ends up in an infinite loop.
- Solution

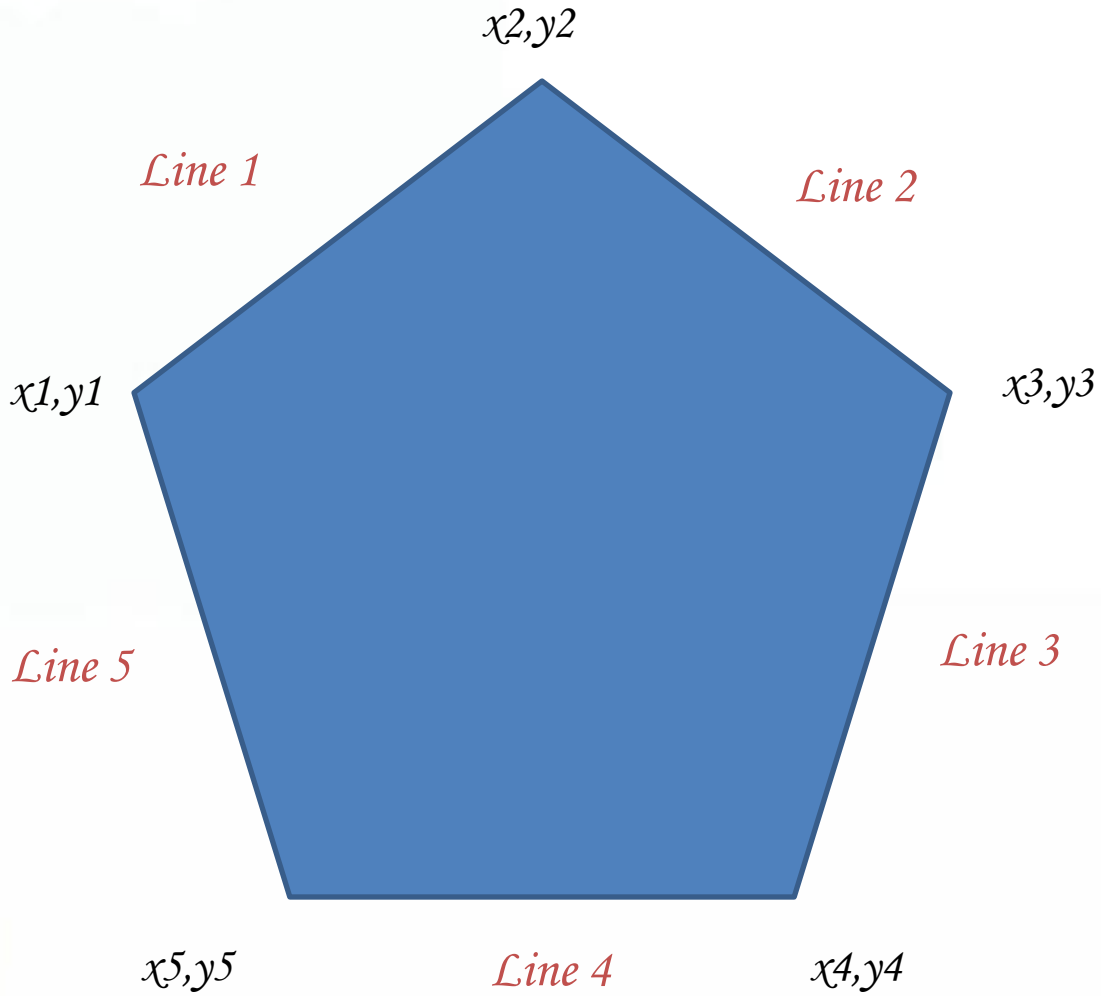
```
% Definition to line
line([[X1,Y1],[X2,Y2]]) :- between(1,10,X1), between(1,10,X2),between(1,10,Y1),between(1,10,Y2).
```

2. Define A Polygon

Basic Requirements

1. Should have more than three lines.
2. First coordinates of a line should be the last coordinates of the previous line.
3. First coordinates of the first line should be equal to last coordinates of the last line.

2. Define a Polygon



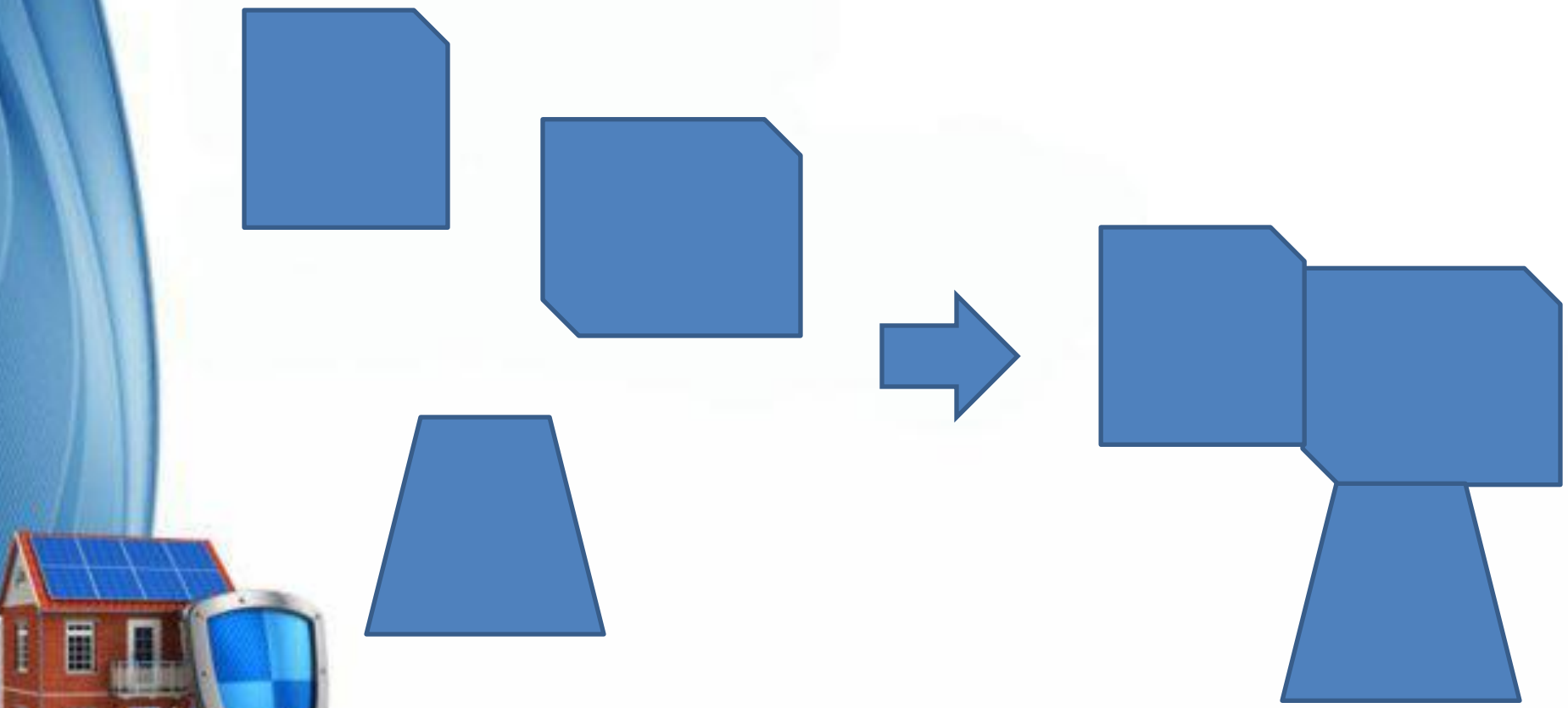
2. Define A Polygon

Prolog Code

```
% Definition to polygon

polygon(X) :- isClosed(X), isConnected(X).

        isClosed([[X1,Y1]|L]) :- last(L, [X2,X1]).

        isConnected([[X1,Y1],[Y1,Z1],[Z1,U1]]):- line([X1,Y1]),line([Y1,Z1]),line([Z1,U1]).

        isConnected([[X1,Y1]|[[Y1,Z1]|L]]):- isConnected([[Y1,Z1]|L]), line([X1,Y1]),line([Y1,Z1]).
```

Just a set of polygon does not represent a house

They should be interconnected



3. Find adjacency of two polygons

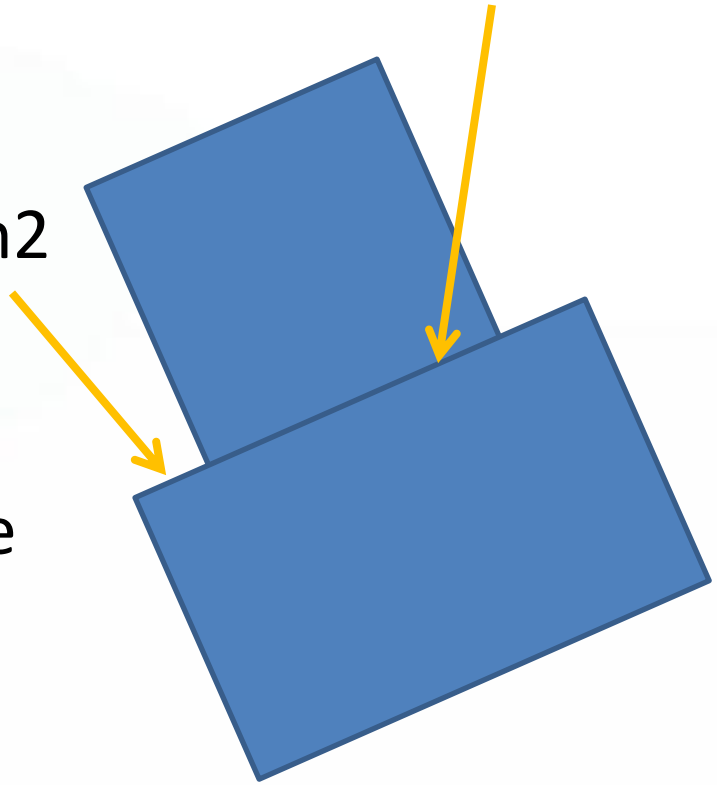
Find a line common to two polygons

Lines should be overlapped

1. Find the slope of line1 in polygon1-> m1

1. Find the slope of
   line2 In polygon2 -> m2

3. Validate m1 = m2 and
   check each coordinate
   lies in same line



3. Find adjacency of two polygons

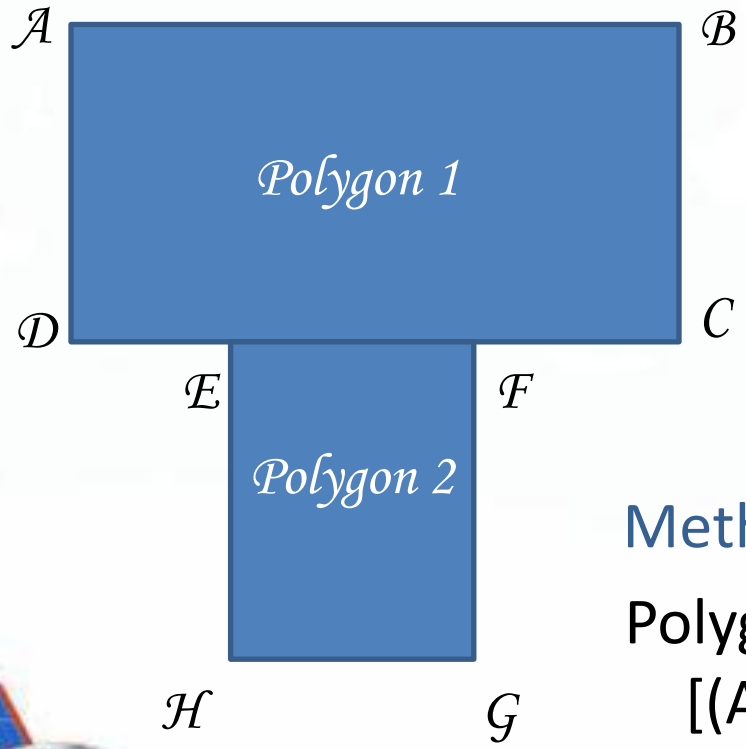
Find a line common to two polygons

- Method
  - ✓Find the slope of lines
- Issues
  - ✓Finding slope needs mathematical calculations like **division**, **square root**
  - ✓Prolog does not support **reverse** calculations for division
- Prolog Code

```
adjacentLine([[X1,Y1],[X2,Y2]],[[X3,Y3],[X4,Y4]], T1, T2) :- T1 is (Y2-Y1)/(X2-X1), T2 is (Y4-Y3)/(X4-X3), T1 is T2, (Y1-Y3)/(X1-X3) = T1, Sqrt(2,(((X1-X2)*(X1-X2))+((Y1-Y2)*(Y1-Y2)))) = (Sqrt(2, (((X1-X3)*(X1-X3))+((Y1-Y3)*(Y1-Y3)))) + Sqrt(2, (((X3-X2)*(X3-X2) + ((Y3-Y2)*(Y3-Y2))))))).
```

3. Find adjacency of two polygons

Solution



Method 1

Polygon 1
[(A,B),(B,C),(C,D),(D,A)]

Polygon 2
[(E,F),(F,G),(G,H),(H,E)]

Method 2

Polygon 1
[(A,B),(B,C),(C,F),(F,E),(E,D),(D,A)]

Polygon 2
[(E,F),(F,G),(G,H),(H,E)]

3. Find adjacency of two polygons

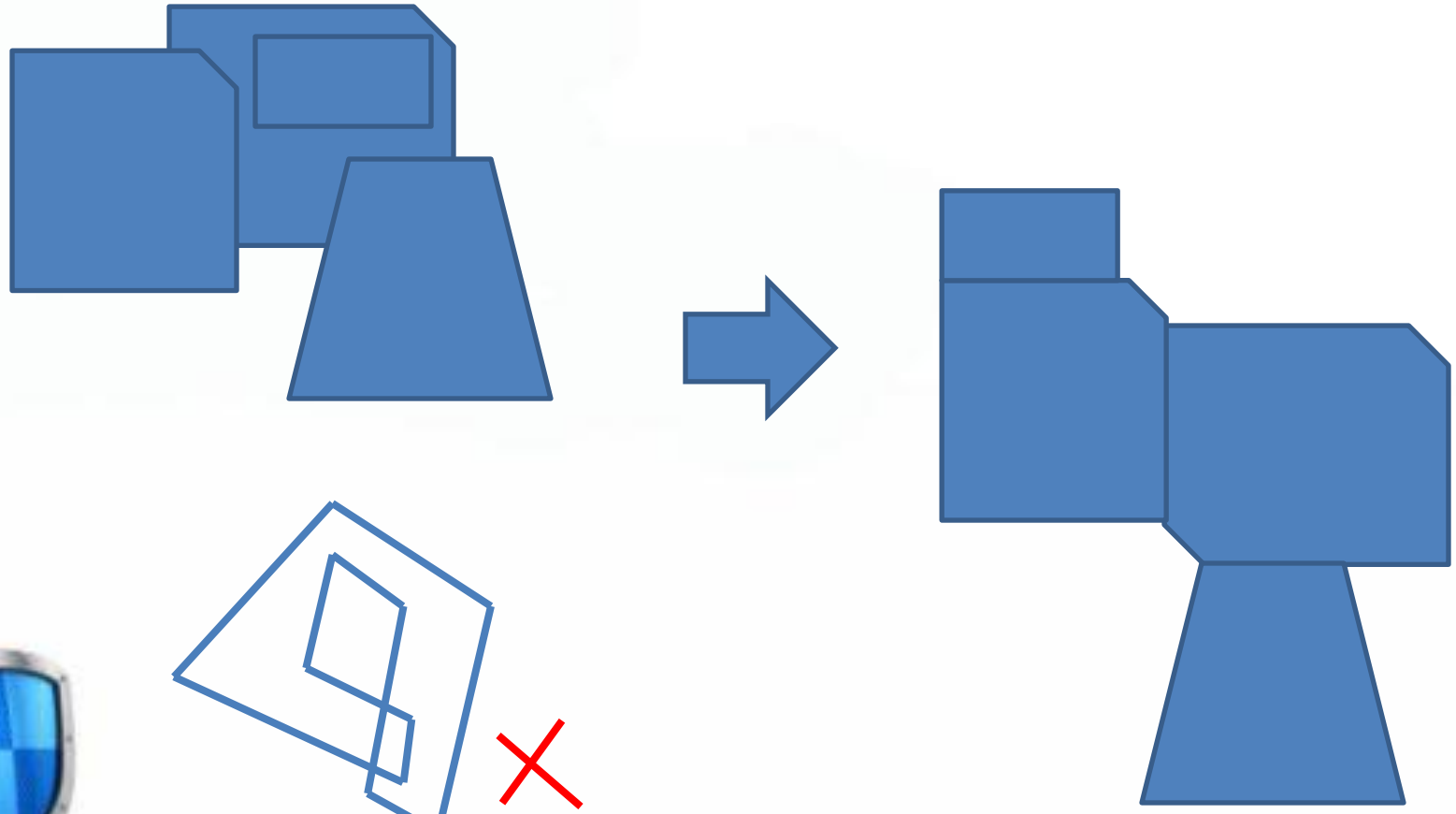
Prolog Code

- Solution
  - ✓Break a polygon line to several lines at the common region of a line

```
% Find the adjacency of two lines

adjacent(X,Y) :-( findNth(X,[A,B]), findNth(Y,[A,B])) ; ( findNth(X,[A,B]), findNth(Y,[B,A]) ).

        % To find a member variable
        findNth([X|T],X) .
        findNth([H|T],X) :- findNth(T,X).
```

Just a set of interconnected polygons does not represent a house

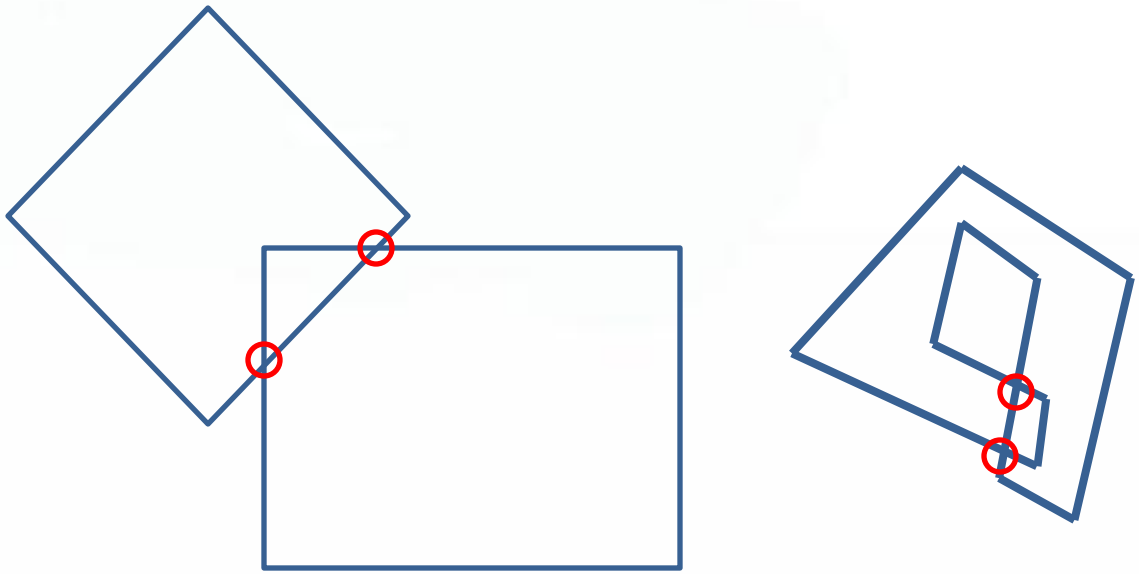
They should not overlap on each other



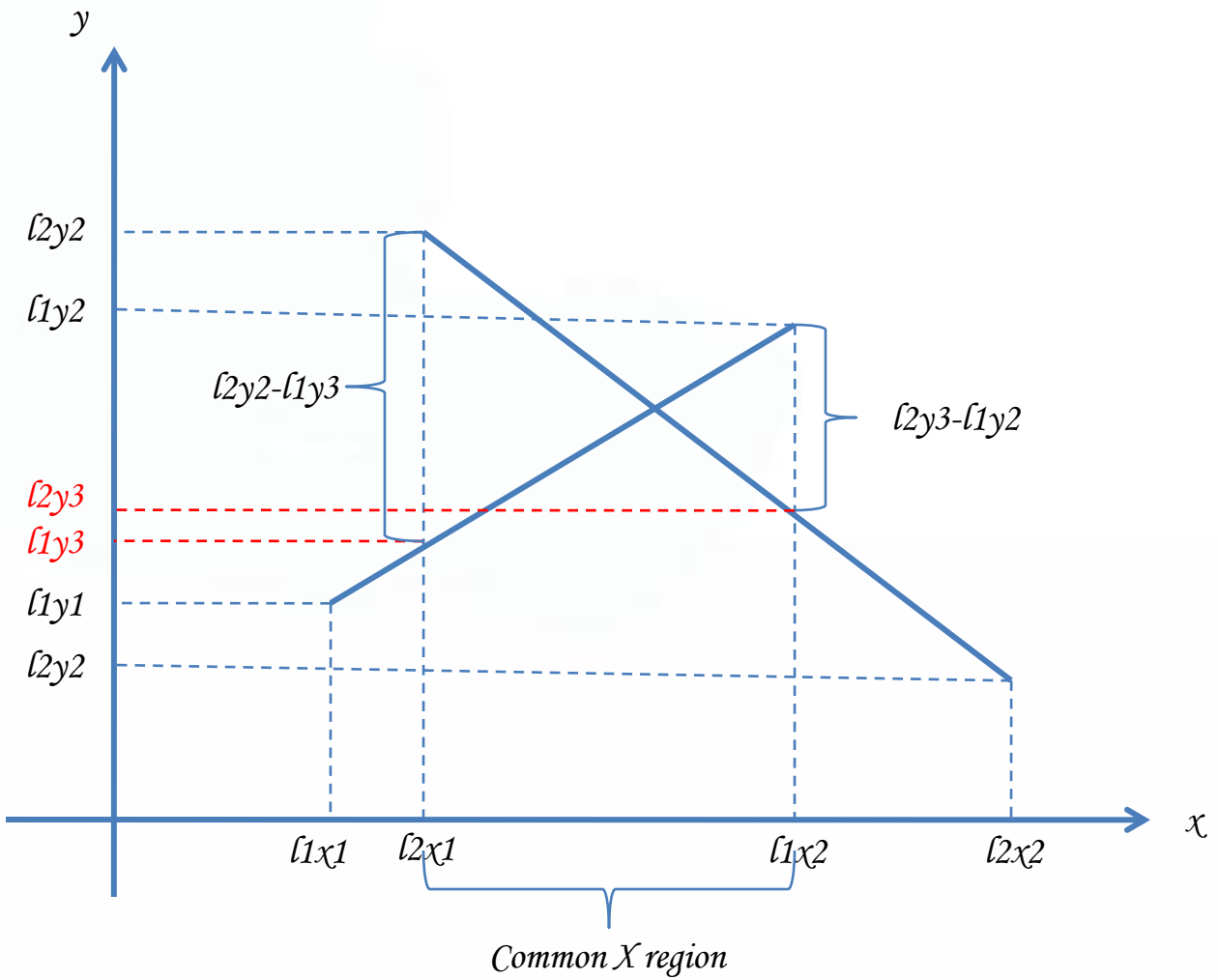
4. Find intersection of two polygons

Find a common point shared by two polygons

- Method
  - ✓Find intersection of two lines



4. Find intersection of two polygons Solution 1



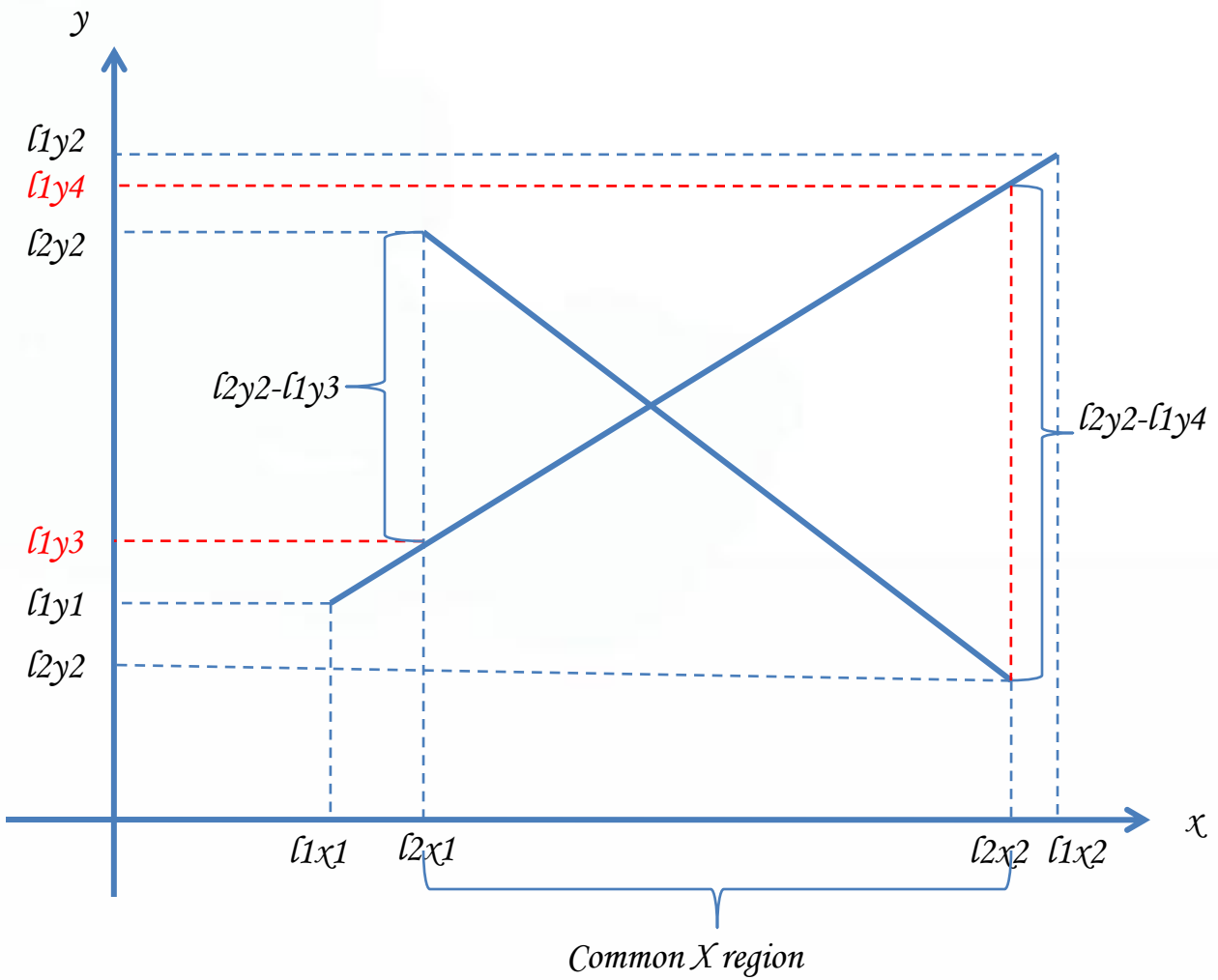
4. Find intersection of two polygons Solution 1(cont)

Equation

$$(l2y2-l1y3) * (l2y3-l1y2) > 0$$

$$\frac{(l2y1-l1y2)(l1x2-l1x1) + (l1y2-l1y1)(l1x2-l2x1)}{(l1x2-l1x1)} * \frac{(l2y1-l1y2)(l1x2-l1x1) - (l2y1-l2y2)(l1x2-l2x1)}{(l2x2-l2x1)} > 0$$

4. Find intersection of two polygons Solution 1(cont)



4. Find intersection of two polygons Solution 1(cont)

Equation

$$(l2y2-l1y3) * (l2y3-l1y2) > 0$$

$$\frac{\overset{+}{(l2y1-l1y2)}\overset{+}{(l1x2-l1x1)} - \overset{+}{(l1y2-l1y1)}\overset{+}{(l1x2-l2x1)} *}{\underset{+}{(l1x2-l1x1)}}$$

$$\frac{\overset{-}{(l2y1-l1y2)}\overset{+}{(l1x2-l1x1)} - \overset{+}{(l2y1-l2y2)}\overset{+}{(l1x2-l2x1)} > 0}{\underset{+}{(l2x2-l2x1)}}$$

4. Find intersection of two polygons Solution 1(cont)

- Prolog Code

```
lineNotIntersect([[L1X1,L1Y1],[L1X2,L1Y2]],[[L2X1,L2Y1],[L2X2,L2Y2]]) :-
    L1X1<L1X2, L2X1<L2X2, (L1X1<L2X1 ; L1X1 is L2X1), (L1X2<L2X2 ; L1X2
    is L2X2), (((L2Y1-L1Y2)*(L1X2-L1X1)) - ((L2Y1-L2Y2)*(L1X2-L2X1))) > 0.


lineNotIntersect([[L1X1,L1Y1],[L1X2,L1Y2]],[[L2X1,L2Y1],[L2X2,L2Y2]]) :-
    L1X1<L1X2, L2X1<L2X2, L1X1<L2X1, L1X2>L2X2, (((L2Y2-L1Y1)*(L1X2-
    L1X1)) - ((L1Y1-L1Y1)*(L2X2-L1X1))) > 0.


checkPolygonInterSection(X,Y) :- append(X,Y,R),checkIntersection(R).


checkIntersection([H,T]) :- lineNotIntersect(H,T).
checkIntersection([H|[H1|T]]) :- lineNotIntersect(H,H1),
    checkIntersection([H|T]), checkIntersection([H1|T]).
```

4. Find intersection of two polygons Solution 1(cont)

- Method
  - ✓Get the common X regions of two lines and get the difference of Y coordinates of two lines at the common X points and the difference should be greater than zero if lines are not intersecting.
- Issues
  - ✓When prolog generates the coordinates of the lines, it generates the coordinates without following a particular order. To apply coordinates to above function coordinates should be in a particular order. **Sorting** the coordinates of a line in prolog is really hard since a coordinate is coupled with it's X and Y values.

4. Find intersection of two polygons Solution 2

- Method
  - ✓Find the common point of two lines using **Bresenham's** line drawing algorithm.
  - ✓Get rid of **divisions** and **square root** calculations
- Issues
  - ✓If the common point lies in a **fraction** value it will not be identified by the Bresenham's algorithm.
  - ✓If a line contains **millions** of pixel points to calculate all the pixel points using this algorithm takes much time and increases the complexity.

4. Find intersection of two polygons Solution 2(cont)

Bresenham's Line-Drawing Algorithm for $|m| < 1$

1. Input the two line endpoints and store the left endpoint in (x_0, y_0).
2. Load (x_0, y_0) into the frame buffer; that is, plot the first point.
3. Calculate constants Δx, Δy, $2\Delta y$, and $2\Delta y - 2\Delta x$, and obtain the starting value for the decision parameter as

$$p_0 = 2\Delta y - \Delta x$$

4. At each x_k along the line, starting at $k = 0$, perform the following test: If $p_k < 0$, the next point to plot is $(x_k + 1, y_k)$ and

$$p_{k+1} = p_k + 2\Delta y$$

Otherwise, the next point to plot is $(x_k + 1, y_k + 1)$ and

$$p_{k+1} = p_k + 2\Delta y - 2\Delta x$$

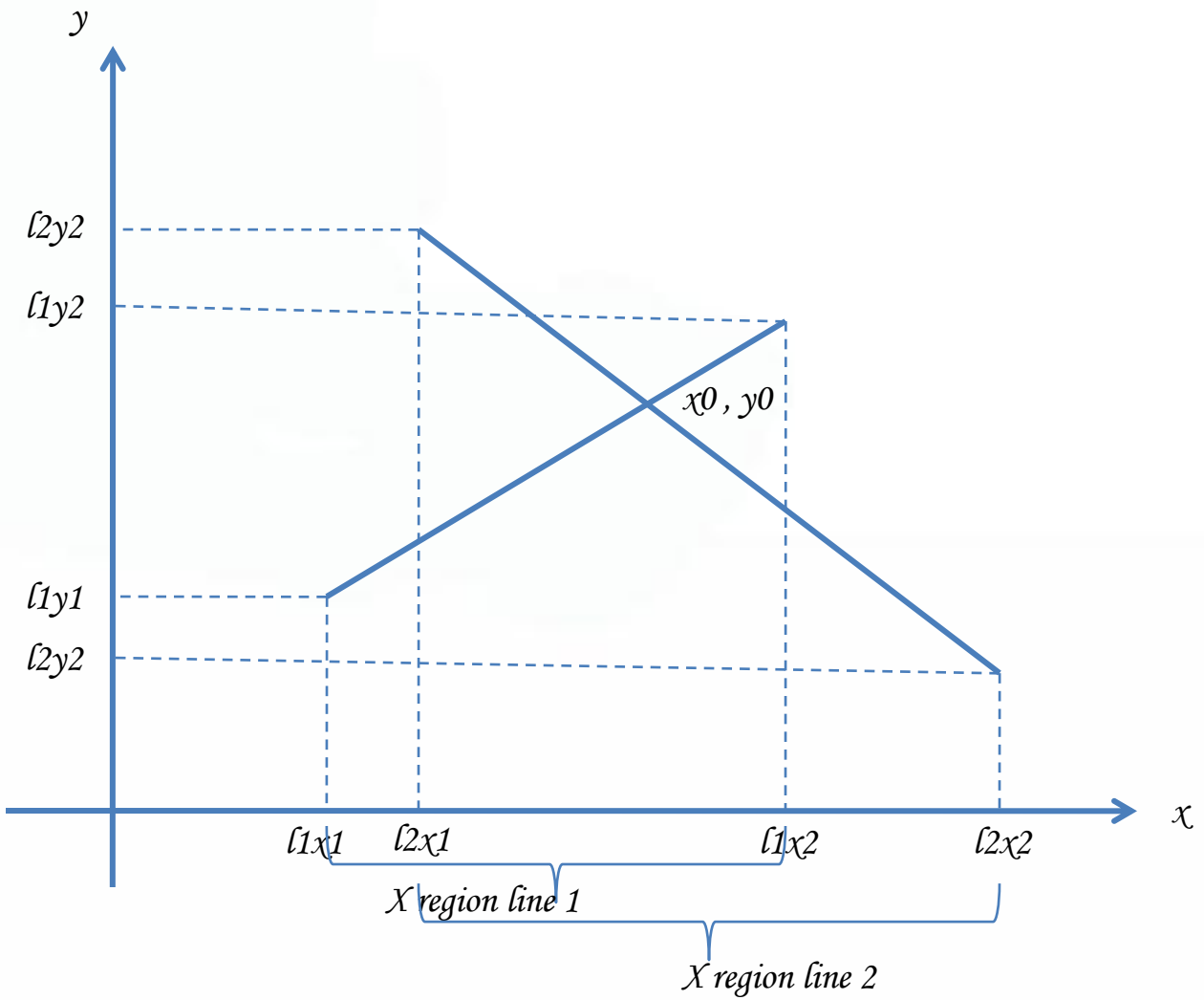
5. Repeat step 4 Δx times.

4. Find intersection of two polygons Solution 2(cont)

- Prolog Code

```
addToList(H,[H|T],T).

addToList(X,[H|T],[H|R]) :- addToList(X,T,R).

checkIntersection([P1,P2], [P3,P4]) :- lineDraw([P1,P2], L1), lineDraw([P3,P4],
    L2), findNth(L1,X), findNth(L2,X).

lineDraw([[X1,Y1],[X2,Y2]],R) :- X1<X2, getPo([[X1,Y1],[X2,Y2]], Po),
    getLine([[X1,Y1],[X2,Y2]],R , Po, DeltaY, DeltaX), DeltaY is Y2-Y1, DeltaX is
    X2-X1.

getPo([[X1,Y1],[X2,Y2]], Po) :- Po is 2*(Y2-Y1) - (X2-X1).

getLine([[X2,Y2],[X2,Y2]],R, Po,  DeltaY, DeltaX).

getLine([[X1,Y1],[X2,Y2]],[H|T], Po,  DeltaY, DeltaX) :- ( Po<0,
    addToList(N,R,[H|T]), N is (X1+1,Y1), Pk1 is Po + (2*DeltaY),
    getLine(N,[X2,Y2],R ,Pk1 ,DeltaY, DeltaX) ) ; ( Po>0,  addToList(N,R,[H|T]), N
    is (X1+1,Y1+1), Pk1 is Po + (2*DeltaY-2*DeltaX), getLine(N,[X2,Y2],R, Pk1,
    DeltaY, DeltaX) ).
```

4. Find intersection of two polygons Solution 3



4. Find intersection of two polygons Solution 3(cont)

- Equation

$$x0 = \frac{(x1*x3*y2 - x2*x3*y1 - x1*x4*y2 + x2*x4*y1 - x1*x3*y4 + x1*x4*y3 + x2*x3*y4 - x2*x4*y3)}{(x1*y3 - x3*y1 - x1*y4 - x2*y3 + x3*y2 + x4*y1 + x2*y4 - x4*y2)}$$

$$l1x1 < x0 < l1x2 \quad AND \quad l2x1 < x0 < l2x2$$

4. Find intersection of two polygons Solution 3(cont)

- Solution
  - ✓Define the intersection point of two lines using coordinates of the two lines and then the common X point should be in the both X coordinates range of lines.
- Challenges
  - ✓To implement above algorithm in prolog I should have to write specific prolog code for

    a) Addition
    b) Multiplication
    c) Comparison

4. Find intersection of two polygons Solution 3(cont)

a) Prolog Implementation for Arithmetic Addition

- Reason
  - ✓ Add two numbers using “+” operator is not supporting reverse functions like subtraction
- Issues Identified in implementation
  - ✓ Implemented prolog code just satisfies adding numbers in **same amount** of number bits
  - ✓ When going to solve above prolog adds **unnecessary zero** values in front of the numbers
  - ✓ **Depth** should be limited since when we call reverse function it ends up in an infinite loop

Prolog Implementation for Arithmetic Addition

```
% Addition

% Addition main function
plus1(A,B,R):-  plusMy(A,B,[0|R]).

        % Ommit unncessary zeros and prepare two lists into same length and call addition predicate
        plusMy(A,B,[0|R]) :- alignTwoLists(A,B,[0|X],[0|Y]), plusMy(X,Y,R).
        plusMy(A,B,[D|C]) :- alignTwoLists(A,B,X,Y), myPlusNew(X,Y,C,D).

                % Prepare two lists in same length by adding zeros infront of the small list, & manage the lists in same length also
                alignTwoLists(X,Y,X,B) :- (longOrEqual(X,Y,R1),addZeros(R1,Z1), append(Z1,Y,B)).
                alignTwoLists(X,Y,A,Y) :-  (longOrEqual(Y,X,R2),  addZerosEqual(R2,Z2), append(Z2,X,A)).

                        % Check whether the lists are in same length and if not return the exceeding elements of long list
                        longOrEqual(X,[],X).
                        longOrEqual([H1|P],[H2|Q],X) :- longOrEqual(P,Q,X).

                        % Provide a list with zeros similar to the number of elements given by above method
                        addZeros([],[]).
                        addZeros([H|X],[0|Y]) :- addZeros(X,Y).

                        % Provide an empty list if the exceeding list is empty
                        addZerosEqual([X],[0]).
                        addZerosEqual([H|X],[0|Y]) :- addZerosEqual(X,Y).

                % Add two numbers similar in length and provide the output
                myPlusNew([A], [B], [C], D) :- da(A,B,C,D).
                myPlusNew([X|A], [Y|B], [Z|R], Q) :- myPlusNew(A,B,R,Q1), da(X,Q1,R2,Q2), da(R2,Y,Z,Q3), da(Q3,Q2,Q,0).
```

```
  0...0994
+ 0...0067
-----------
    1061
-----------
    1  1
```

4. Find intersection of two polygons Solution 3(cont)

b) Prolog Implementation for Arithmetic Multiplication

- Reason
  - ✓ Multiply two numbers using "*" operator is not supporting reverse functions.
- Issues identified in implementation
  - ✓ Adding **zero** elements to **front** and **end** of the number lists.
- Solution
  - ✓ Adding zeros to front of the lists has been already solved by prolog addition implementation
  - ✓ Solved adding zeros to end of the result of row multiplication

4. Find intersection of two polygons Solution 3(cont)

b) Prolog Implementation for Arithmetic Multiplication

```
% Multiplication

% Multiply two lists of numbers
multiplicatn([X|A],[B],W) :- multiplyRow([X|A],B,W,0).
multiplicatn([X|A],[Y|B],W) :- multiplyRow([X|A],Y,R1,0),addZerosMul(B,Z),append(R1,Z,R3),plus1(R2,R3,W),multiplication([X|A],B,R2).

        % Calculate appropriate number of zeros to add at the end of result of multiplication of a row
        addZerosMul([],[]).
        addZerosMul([H|X],[0|Y]) :- addZeros(X,Y).

        % To multiply a row by a particular number
        multiplyRow([X],M,[R],Q) :- mul(X,M,R,Q).
        multiplyRow([X|A],M,[Y|R],Q) :- multiplyRow(A,M,R,Q2), mul(X,M,N,L), da(N,Q2,Y,F), da(F,L,Q,0).
```

```
  194 *
   67
-------
 01358   2
 11640
-------
 12998   0
-------
```

4. Find intersection of two polygons Solution 3(cont)

c) Prolog Implementation for Arithmetic Comparison

- Reason
  - ✓ Comparison of two numbers using "< and >" operators are not supporting reverse functions.
- Issues identified in implementation
  - ✓ Adding **zero** elements to **front** of the number lists.
- Solution
  - ✓ Adding zeros to front of the lists has been already solved by prolog addition implementation

Prolog Implementation for Comparison

```
% Comparison

% Main predicate of comparison
compare(X,Y) :- alignTwoLists(X,Y,P,Q), compareInner(P,Q).

        % Prepare two lists in same length by adding zeros infront of the small list, & manage the lists in same length also
        alignTwoLists(X,Y,X,B) :- (longOrEqual(X,Y,R1),addZeros(R1,Z1), append(Z1,Y,B)).
        alignTwoLists(X,Y,A,Y) :-  (longOrEqual(Y,X,R2),  addZerosEqual(R2,Z2), append(Z2,X,A)).

                % Check whether the lists are in same length and if not return the exceeding elements of long list
                longOrEqual(X,[],X).
                longOrEqual([H1|P],[H2|Q],X) :- longOrEqual(P,Q,X).

                % Provide a list with zeros similar to the number of elements given by above method
                addZeros([],[]).
                addZeros([H|X],[0|Y]) :- addZeros(X,Y).

                % Provide an empty list if the exceeding list is empty
                addZerosEqual([X],[0]).
                addZerosEqual([H|X],[0|Y]) :- addZerosEqual(X,Y).

        % Inner predicate of comparison
        compareInner([T1],[T2]) :- large(T1,T2).
        compareInner([H1|T1],[H2|T2]) :- compareInner(T1,T2), H1 is H2.
```

153<156

053<156

003<156

Write the output of a predicate to text file

1. line(A,B), open('out.txt', write, Out), write(Out,N), close(Out).

Graphic design in Visual Studio IDE

1. Read the text file output in visual studio
2. Generate a polygon

Knowledge Base Implementation Next Phase

1. Geometrical Rules
   a. Find a polygon inside a polygon
2. Architectural Rules
3. Legal Rules

Thank You

Find overlapping of two polygons

Count intersecting points

- Method
  - ✓Draw a line from the middle point of a line to other polygon and count the points that intersect other polygon.
  - ✓If count gives an odd value polygons are not intersecting.
  - ✓If count gives even value polygons are intersecting.

Find intersection of two polygons Solution 3(cont)

Prolog Implementation for Arithmetic Addition

- Solution
  - ✓ If two lists are in same length I should have to define a specific method to skip adding zeros to that list.

  - ✓ Depth limit
  - ✓ Visual studio – graphical display
  - ✓ Write to text
  - ✓ Read from text

Find overlapping of two polygons

Count intersecting points