Algorithm Animation in PDF Documents

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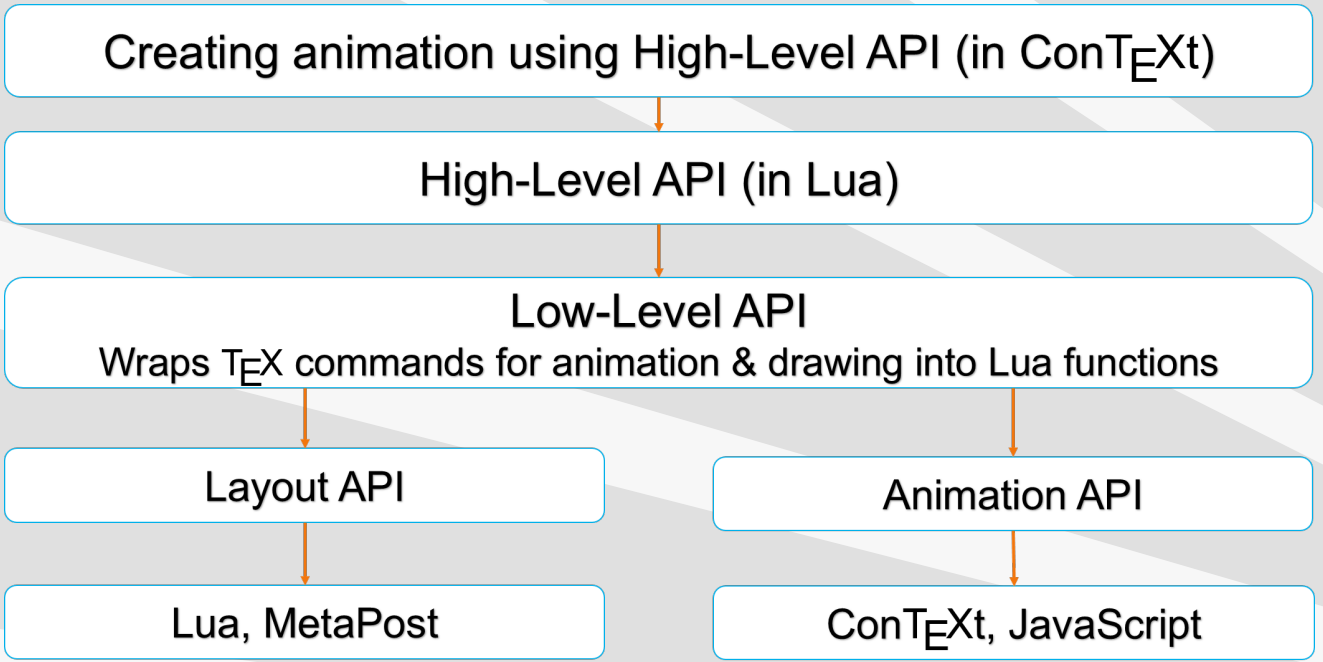
Abstract

- Incorporate animated diagrams in PDF documents for educational purpose.
- ConTEXt (typesetting macro based on TEX) to generate the PDF documents.
- Animation is a sequence of layers with capabilities to play, pause, resume and rewind.
- A module for animation in ConTEXt with JavaScript.
- Animate algorithms for well-known data structures. Automatic layout of diagrams for arrays, lists, trees, and graphs.

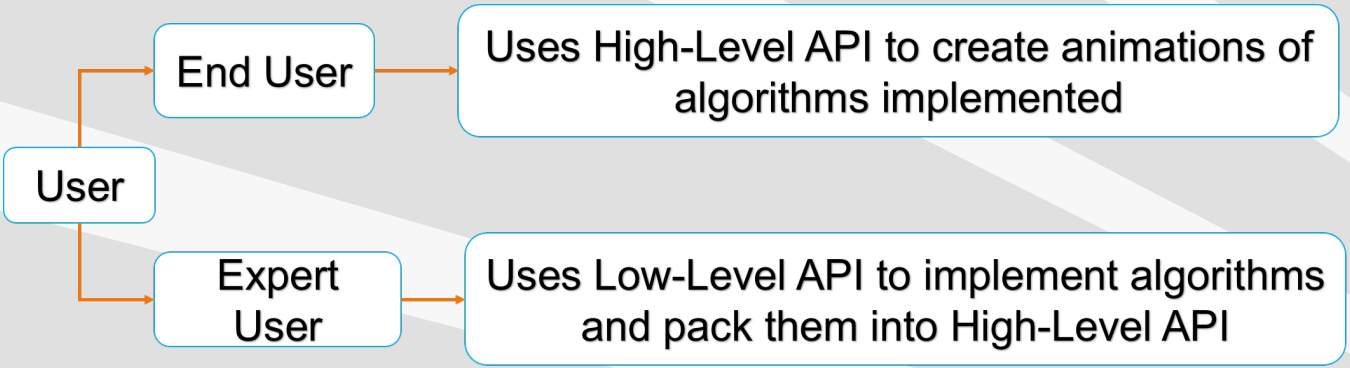
Design and Implementation



Major Work

- Standardize the Low-Level API and demonstrate its use with examples to create the High-Level API.
- Adapt the base JavaScript file of ConTEXt which is used by the t-animation module to our animation needs.
- Create an interface to display the algorithm with its statements highlighted in sync with the animation of the data structure diagrams.

User Classification



Layout API

- Arrays
- Lists
- Trees
- Graphs

Layout API — Arrays

- Boxes joined together create an array structure.
- To join the boxes, we use the following command

```
box.join(a.ne=b.nw;a.se=b.sw;)
```

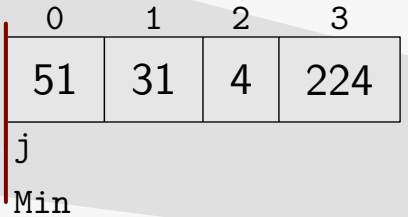
Example:

Sorting of an Array - Selection Sort

```
selectionSort({51,31,4,224,23})
```

Arrays — Examples

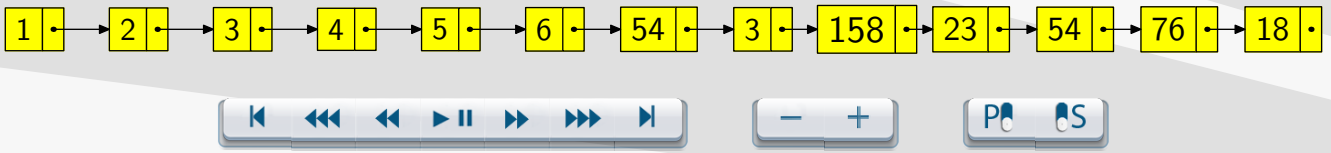
```
for j=1,n,1 do
    iMin = j
    for i = j+1,n,1 do
        if a[i] < a[iMin] then
            iMin = i
        end
    end
    swap(j,iMin)
end
```



Layout API — Lists

- Two ways of representing Lists
  - Abstract or Circular
  - Detailed or Rectangular
- Nodes are connected with arrow heads.
- Markers to show currently accessed node.

```
deleteListNodes({4,18},{1,2,3,4,5,6,54,3,158,23,54,76,18})
```



Layout API — Trees

- Binary Trees.
- Node at same depth are spaced out evenly in X axis.
- To accommodate more nodes in the tree diagram, as depth increases, spacing is reduced proportionately.

Example :
Insertion in Binary Search Tree

```
bstCreate({50,25,75,12,37,63,87,6,18,31,43,57,69,81,93})
```

Trees - Example

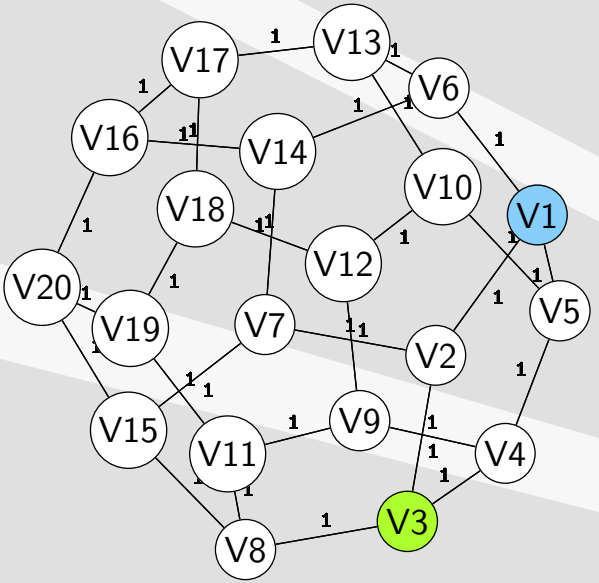
Layout API — Graphs

- Force-Directed Algorithm – application of force to nodes and edges.
- Aesthetically pleasing - Less Crossings.
- Edges of almost equal length.

Example :
Applying Dijkstra's algorithm

```
dijsktra(adjacencyMatrix,startVertex,endVertrex)
```

Graphs - Example



Fitting Diagrams in a Page

- Diagrams have to be accommodated within the PDF page regardless of the number of nodes in a diagram.
- Scaling the nodes as the no. of nodes increases is useful.

$$Scaling\ Factor\ \alpha\ \frac{1}{No.\ of Nodes}$$

- But decreasing the scaling factor might alone is not enough to get the diagram inside the page.

Fitting Diagrams in a Page

- When there is a large number of nodes, the readability of the diagram decreases.
- When the number of nodes exceeds a threshold, represent them by dots. The threshold depends on the data structure.

Data Structure	**Threshold(in no. of nodes)**	
Array	80	
List	Abstract	Detailed
	80	60
Tree	6 (Depth of Tree)	
Graph	50	

Animation API

- ConTEXt uses fieldstack mechanism to create overlapping layers (frames) written in JavaScript. This is crude and cannot be directly used to create animations. A third-party module, t-animation, makes it usable to create animations; yet, it has only minimal features.
- Added three priority levels for frames:
  (i) Sequential Frames (ii) Normal frames, and (iii) Breakpoints.
- This leads to adding the following features
  - Automatically pause at breakpoints
  - Automatically skip sequential frames

Animation API

- The module supports options to play, pause, go to - next frame, previous frame, first frame, and last frame.
- We have added the following options
  - Increase/Decrease animation speed
  - Toggle automatic pasue at breakpoints
  - Toggle skipping of sequential frames
  - Go to — next breakpoint, previous breakpoint

Performance Analysis

No. of Frames	Time to Compile
53	0:04
88	0:10
392	1:05
886	3:53
1279	8:29
1663	11:12

Conclusion

- Efficient Low-levl API for the creation of data structure diagrams and animation.
- Examples for creating algorithm animations using the Low-level API.
- Pseudo-Code is displayed alongside the animation, making it easy to follow.

References

- Personal correspondence with Wolfgang Schuster, the author of t-animation module of ConTEXt.
  E-mail: wolfgang.schuster@gmail.com
- Yifan Hu. Efficient and High-Quality Force-Directed Graph Drawing, Wolfram Research Inc., USA.
- John D. Hobby. Drawing Boxes with MetaPost. [Online].
  Available: http://www.tug.org/docs/metapost/mpboxes.pdf
- Dennis Hotson. Springy.js – A force directed graph layout algorithm in JavaScript. [Online]
  Available: http://getspringy.com/