CS 220: Survey of Programming Languages

Lecture Slides

Dataflow Programming Languages

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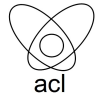
Session 9



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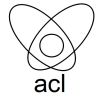

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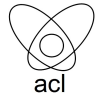

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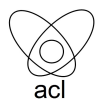

http://paginas.fe.up.pt/∼prodei/dsie12/papers/paper_17.pdf

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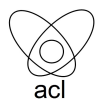

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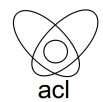

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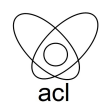

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- Aim is to change the state of the variables by focusing on the operations needed to be performed.
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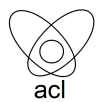
  - Sequentially apply operations based on order of statements/expressions
- (Sequential) Operator/Function-centric view of computation



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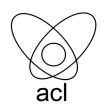

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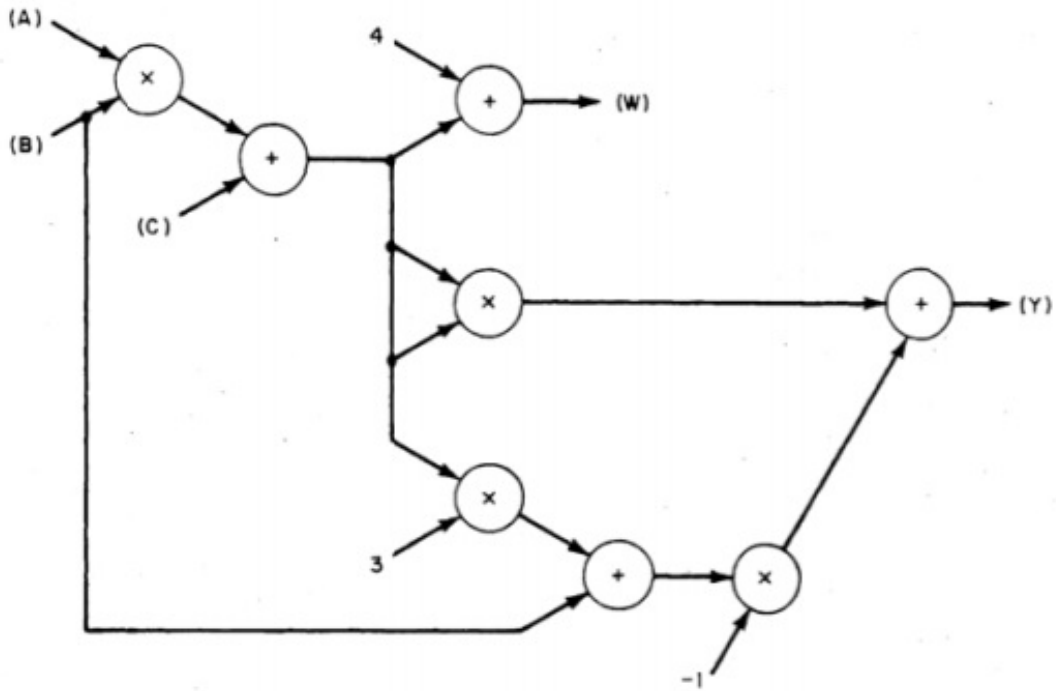

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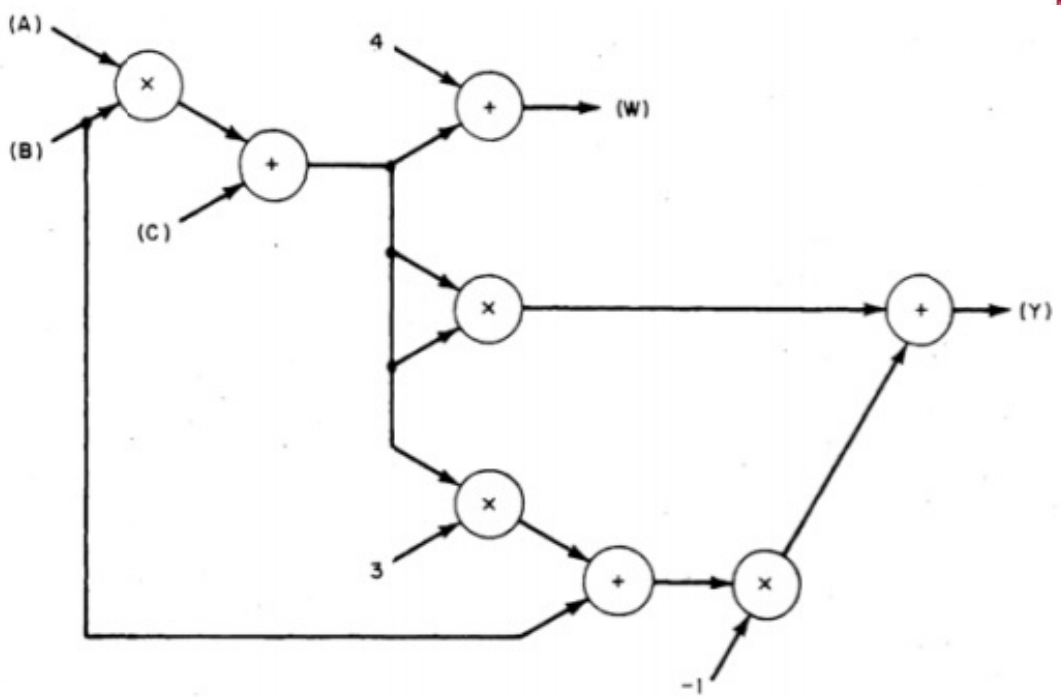

- Dataflow graph

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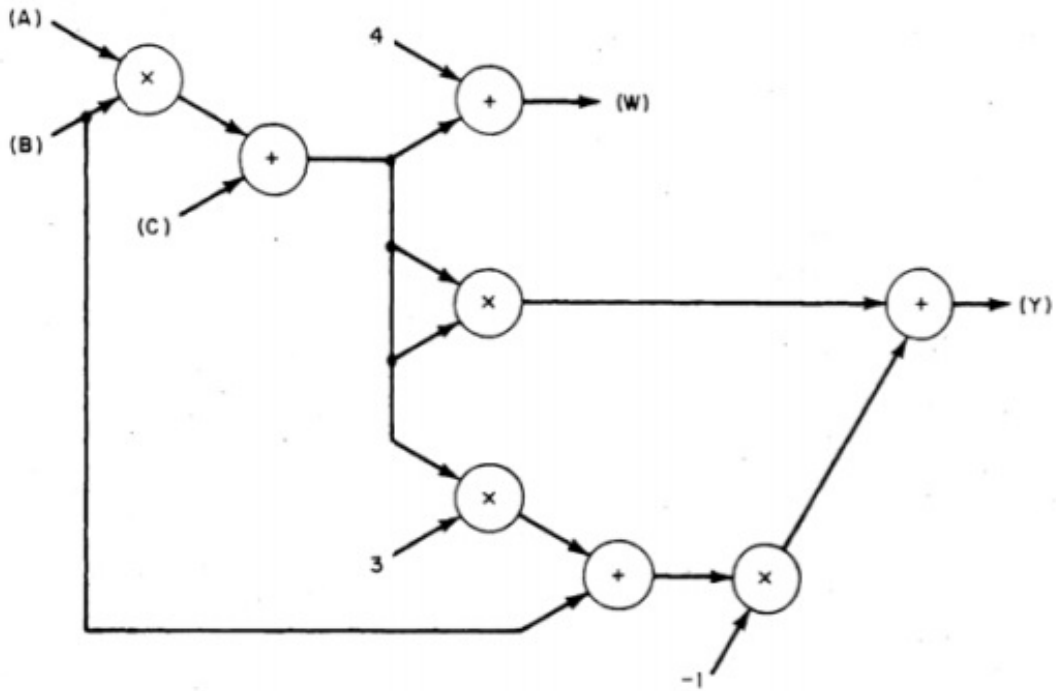

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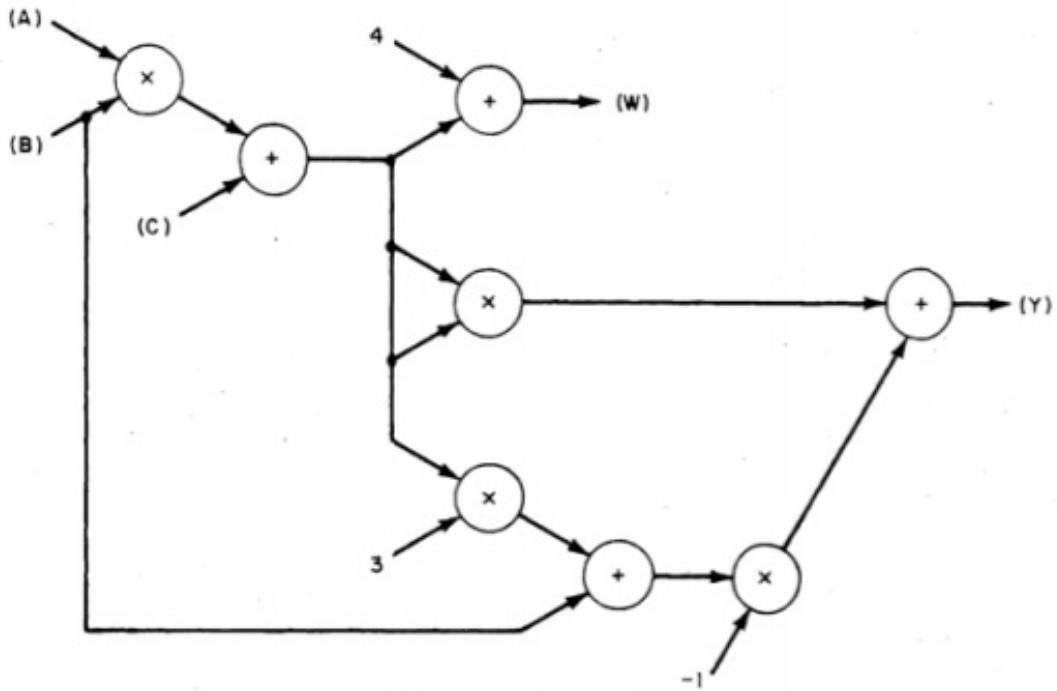

- Dataflow graph
- From focusing on which operator to operate first to focus on which variables/data to move towards an operation
- Possible parallelization of independent operations

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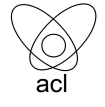
Characteristics of a dataflow PL



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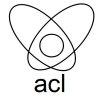

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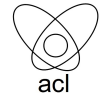

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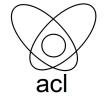

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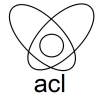
  - Distributor valves take in an input token and uses a (Boolean) control token to send the input to one of 2 possible output arcs (representing "true" and "false")



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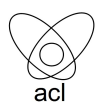

[3] http://paginas.fe.up.pt/∼prodei/dsie12/papers/paper_17.pdf

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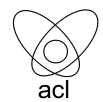

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- Advantages[3]
  - Inherent concurrency
  - Existence of visual implementations of dataflow PLs

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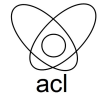
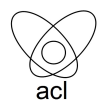
Dataflow Programming Languages



Background



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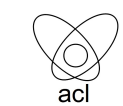
http://paginas.fe.up.pt/∼prodei/dsie12/papers/paper_17.pdf
http://csg.csail.mit.edu/Users/dennis/barc-presentation/sld015.htm

Background

- Streams and Iteration in a Single Assignment Language



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- Developed in 1985 as a derivative of VAL (Variable Assembly Language)

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- Developed in 1985 as a derivative of VAL (Variable Assembly Language)
- Language has Pascal-like syntax
- "The language intended to compete in performance with Fortran while using the dataflow model to introduce parallel computation in the first multi-core machines."
  - "... [M]icro-tasking environment [was provided to support] dataflow architecture on traditional single-core machines."

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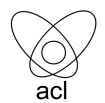

[4]Proceedings of Future Parallel Computers: An Advanced Course in Pisa, Italy, June 9-20, 1986, pp. 112-115

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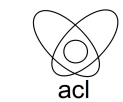

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    - Union types are choice types

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Evaluation

- Syntax design (Based on the grammar of a Javascript interpreter for SISAL[5]):

[5] https://github.com/parsifal-47/sisal-js/blob/master/helpful_data/sisal30bnf.txt#
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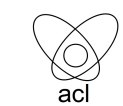

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- Abstraction:

[8] Proceedings of Future Parallel Computers: An Advanced Course in Pisa, Italy, June 9-20, 1986, p. 113-115

[9] http://www2.cmp.uea.ac.uk/∼jrwg/Sisal/14.Funcs.progs.html

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- Expressivity: Has no built-in libraries (save for the core), but can access native libraries of operating systems [9]
- Exception handling: Done by (explicitly) generating error values, and preserving component values known to be correct prior to generation of error values. [10]

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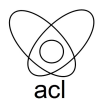

[11] RA Finkel, Chapter 6

[12] http://paginas.fe.up.pt/∼prodei/dsie12/papers/paper_17.pdf

Evaluation

- Restricted aliasing: Since it is a derivative of VAL, aliasing is not allowed at all in SISAL[11]

[11] RA Finkel, Chapter 6
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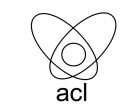

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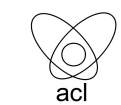

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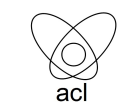

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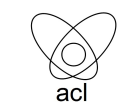

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    - Compiler is responsible for building the dataflow graph
    - Each node is executed by an independent thread
    - Data processing is done upon arrival at a node, and forwarded along the dataflow chain
  - "In some benchmarks, SISAL was able to outperform Fortran in computation performance"

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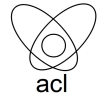
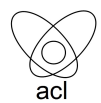
Dataflow Programming Languages



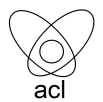
Background



http://www.tau.ac.il/∼flaxer/edu/course/vhdl/slides/VHDL01.pdf

Background

- Hardware design languages (HDLs) allow for quick design, implement, test, and document, complex digital systems



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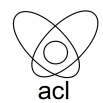
- VHDL stands for Very High Speed Integrated Circuit (VHSIC) Hardware Description Language



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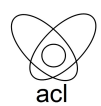
- VHDL stands for Very High Speed Integrated Circuit (VHSIC) Hardware Description Language
- Created by the US Department of Defense to document military designs for portability, a standard of the language of which was adopted in 1987



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Evaluation

- Data types[13]

[13] http://cseweb.ucsd.edu/∼tweng/cse143/VHDLReference/04.pdf
[14] http://tams-www.informatik.uni-hamburg.de/vhdl/tools/grammar/vhdl93-bnf.html
[15] Manually counted

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- Data types[13]
  - Integers, bits, characters, logical, and enumeration as primitive types

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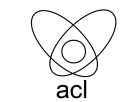

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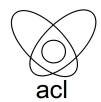

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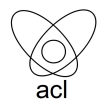

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  - Comparable to assembly language programming

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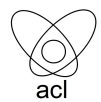

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  - Best practice for exception handling: "...[I]ntroduce an explicit [outer] loop and the outset of the process which handles normal processing."

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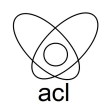

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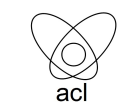

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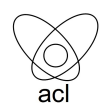

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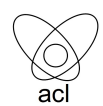

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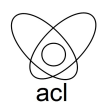

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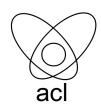

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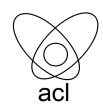

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  - (Bit) Arrays are more efficient than individual (bit) variables

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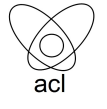
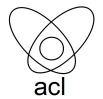
Dataflow Programming Languages

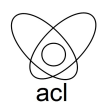


Background



Background

- Pure Data is an open source visual programming language



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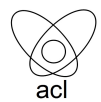
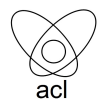
- Pure Data is an open source visual programming language
- Derived from the Max programming languages and developed by Miller Puckette in the 1990's



Background

- Pure Data is an open source visual programming language
- Derived from the Max programming languages and developed by Miller Puckette in the 1990's
- "[Pure Data] enables musicians, visual artists, performers, researchers, and developers to create software graphically, without writing lines of code."



Evaluation

- Data types[22,23]

[22] http://www.pd-tutorial.com/english/ch02s02.html#id412354
[23] http://en.flossmanuals.net/pure-data/network-data/osc/

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- Data types[22,23]
  - Integer, single and double precision floating point real numbers, string, logical, and signals as primitive data types

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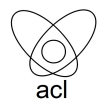

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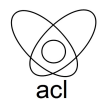
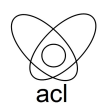
[22] http://www.pd-tutorial.com/english/ch02s02.html#id412354
[23] http://en.flossmanuals.net/pure-data/network-data/osc/



Evaluation

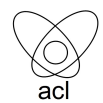
- Syntax design



http://www.pd-tutorial.com/english/ch02.html

Evaluation

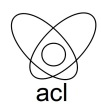
- Syntax design
  - No grammar specification found, (number of) usable objects and keywords will be used instead as indicator
  - Surface objects: 16, each with varying number of inlets and outlets
  - Keywords: 187



http://www.pd-tutorial.com/english/ch02.html

Evaluation

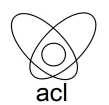
- Syntax design
  - No grammar specification found, (number of) usable objects and keywords will be used instead as indicator
  - Surface objects: 16, each with varying number of inlets and outlets
  - Keywords: 187
  - The use of the "Object" surface object spans several usages, from declaration of lists, printing out variables, creating expressions to invoking operations and functions



http://www.pd-tutorial.com/english/ch02.html

Evaluation

- Syntax design
  - No grammar specification found, (number of) usable objects and keywords will be used instead as indicator
  - Surface objects: 16, each with varying number of inlets and outlets
  - Keywords: 187
  - The use of the "Object" surface object spans several usages, from declaration of lists, printing out variables, creating expressions to invoking operations and functions
  - In addition, some of the capabilities of the "Object" surface object can be performed in the same manner as the "Message' surface object



http://www.pd-tutorial.com/english/ch02.html

Evaluation

- Abstraction: Can be achieved via subpatch(ing of operations) and streamlining subpatches[25]

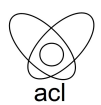
[25] http://www.pd-tutorial.com/english/ch05.html
[26] http://www.pd-tutorial.com/english/ch03.html
[27] http://www.pd-tutorial.com/english/ch04.html
[28] http://www.pd-tutorial.com/english/ch02s02.html
[29] http://www.pd-tutorial.com/english/ch04s04.html

Evaluation

- Abstraction: Can be achieved via subpatch(ing of operations) and streamlining subpatches[25]
- Expressivity: Has rich set of functionalities, but mostly for audio signal processing and music generation[25,26,27]

[25] http://www.pd-tutorial.com/english/ch05.html
[26] http://www.pd-tutorial.com/english/ch03.html
[27] http://www.pd-tutorial.com/english/ch04.html
[28] http://www.pd-tutorial.com/english/ch02s02.html
[29] http://www.pd-tutorial.com/english/ch04s04.html



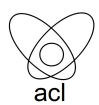


Evaluation

- Abstraction: Can be achieved via subpatch(ing of operations) and streamlining subpatches[25]
- Expressivity: Has rich set of functionalities, but mostly for audio signal processing and music generation[25,26,27]
- Exception handling: No special mechanism for exception handling, but can be done via proper rerouting of a particular condition to a corresponding operation [28,29]

[25] http://www.pd-tutorial.com/english/ch05.html
[26] http://www.pd-tutorial.com/english/ch03.html
[27] http://www.pd-tutorial.com/english/ch04.html
[28] http://www.pd-tutorial.com/english/ch02s02.html
[29] http://www.pd-tutorial.com/english/ch04s04.html





Evaluation

- Abstraction: Can be achieved via subpatch(ing of operations) and streamlining subpatches[25]
- Expressivity: Has rich set of functionalities, but mostly for audio signal processing and music generation[25,26,27]
- Exception handling: No special mechanism for exception handling, but can be done via proper rerouting of a particular condition to a corresponding operation [28,29]
- Restricted aliasing: No (explicit) aliasing begin done

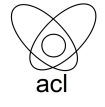
[25] http://www.pd-tutorial.com/english/ch05.html
[26] http://www.pd-tutorial.com/english/ch03.html
[27] http://www.pd-tutorial.com/english/ch04.html
[28] http://www.pd-tutorial.com/english/ch02s02.html
[29] http://www.pd-tutorial.com/english/ch04s04.html

Evaluation

- Efficiency

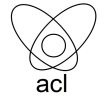
Evaluation

- Efficiency
  - Employs dynamic type-checking



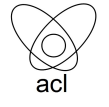
Evaluation

- Efficiency
  - Employs dynamic type-checking
  - Pure Data is an interpreted language



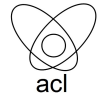
Evaluation

- Efficiency
  - Employs dynamic type-checking
  - Pure Data is an interpreted language
  - Significant delays in creation of large arrays and graph



Evaluation

- Efficiency
  - Employs dynamic type-checking
  - Pure Data is an interpreted language
  - Significant delays in creation of large arrays and graph
  - Prone to stack overflow errors due to combined memory requirement of interpreter itself and requirement of execution



END OF SESSION 9