

Modelling Cognition

Matthew Hinton^{1*} and Preston Pan^{2†}
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¹University of Victoria

Abstract

Cognition is a system wherein components of the language are public to the language itself. It is written in pure postfix notation, and removes the prefix characteristics of other similar languages. This enables the Cognition interpreter to be able to manipulate its state based on code read on the fly in a token stream, giving it the property of tokenizing and parsing future characters differently than it does current characters. The result is an unopinionated language that can replicate a wide variety of different syntaxes, allowing Cognition to modify syntax entirely during runtime. This paper investigates the implications of this programming language, which has potential applications in parsing and self-modifying systems.

1 Introduction

Current programming languages operate with parsing requirements. This means that the parser must read ahead of the current token to decide what to do with the current token being passed into the parser. This usually causes the language to have a static syntax, due to the parser being too rigid for the AST to be made public. Metaprogramming languages solve this problem by making parts of the AST public, and in particular, concatenative programming languages such as forth, factor, and stem solve a part of this problem by introducing postfix notation for symbols usually known as *words*, which reduce the need for parsing by allowing tokens to be evaluated one-at-a-time. Many of these languages then utilize metaprogramming in order to alter the execution order of the tokens, usually using quotes. However, they don't remove the requirement of *reading ahead*. Instead, they outsource this process to quotes, which are required for turing completeness in the form of recursion. Worse, many of these languages have strings, which require the parser or tokenizer to read ahead in order to package the string as a single token. Therefore, many of these languages are not perfect candidates for a perfectly postfix language.

Cognition solves this problem using three mechanisms: first, tokens are one character long by default and information about how Cognition will tokenize based on certain delimiter rules are made public to the language; second, Cognition uses a unique metacrank system which allows it to modify the execution order of the code, allowing Cognition to *modify the syntax for changing the execution order itself* due to the metacrank system's postfix syntax, and allow for metaprogramming; third, it uses what we call an *falias* system which we believe to be equivalent to

metacrank, but makes for easier bootstrapping to an environment that is more desirable to program in.

2 Language Design

As of the release of this paper, the language design is incomplete yet still covers many general cases. Trade-offs in the implementation have been made such that the essence of the design is there but the implementation is simplified. In this section, we describe the high level overview of the public components of Cognition, and we compare and contrast it with other similarly flexible programming languages such as Forth and Lisp.

In languages like lisp and forth, syntax can be modified using *macros*. The usage of macros allows for the publicity of the AST; that is, it allows for the change in execution order of symbols or words. Similarly, Cognition allows for this behavior, by using a *metacranking* system, which allows it to specify every *n*th word *n* items down the stack to be executed, where all the other words are not evaluated. Metacranking behavior can be modified using a postfix syntax, allowing metacrank execution order itself to be changed, meaning not only can the AST be modified, but the system used to modify the AST is itself a part of the AST and can be modified. This allows full AST modification, and we believe it to not be possible with many more naive implementations of Forth and many, if not all implementations of Lisp.

Because everything is written in postfix notation, there is almost no need for a special character that denotes the AST like in the case with the parentheses in Lisp. Instead, there is an *falias* system which force evaluates the top item on the stack in a *fast* way, without waiting for the cranker. It is conceptually possible to modify the bracket syntax for lisp and for Forth, but it is unwieldy due to its prefix nature.

*Corresponding author: matthewhinton@uvic.ca

†Corresponding author: preston@nullring.xyz

This gives Cognition the benefit of never reading ahead. Because it never has to read more characters than it has to, only obeying a couple of delimiter, ignored character, and singlet laws, it allows the tokenization strategy of the parser to be changed without affecting the current token or future tokens in unwanted or conflicting ways. This allows other special characters that denote the delimiter between different tokens, for example, to be made public, and allows them to therefore be changed dynamically and programmatically, giving even more power to the AST manipulation as operations modifying the tokenizer can be stored in the stack and changed via the metacranker. Furthermore, string operations in Cognition modify the tokens post-tokenization, making post tokenization decisions about token execution possible.

The hash table that stores variable definitions is also made public, allowing the program to access currently defined variables, modify them, and delete them. This principle is made more powerful with metastack operations which have the main focus of reducing the possibility of hash table collisions and making program simulation and program introspection easy.

Metastack operations extend the definition of Forth quotes, attaching a hash table and other data structures required to make a complete cognition environment to quotes, making them self similar to the original environment. This is important for implementing scope, containerization, and self-simulation. This allows Cognition to be used as a permission system in a Cognition-centric virtual machine or operating system in the future.

2.1 Parser Design

The parser is designed to make public the specifics of how characters are parsed into tokens by delimiter rules, and by a few other constructs called *ignores* and *singlets*. Ignores allow the parser to ignore a list of characters at the start of the read-eval-print loop, and delimiters and singlets allow the parser to determine the end of the next token.

The parser has three flags for these features, where the flags represent the decision to whitelist or blacklist the characters to be ignored, or to be singlets or delimiters that stop the parser from collecting the token. When the parser hits a delimiter, the parser stops and the token gets packaged, whereas when the parser hits a singlet, the parser skips the singlet character. This enables a wide range of source file text manipulation. If characters were not ignored, at least one character must be parsed into a word, and if not, a word containing no characters can be created with singlets.

2.2 Metacrank Design

2.3 Metastack Design

2.4 Builtins

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2.5 Species Identification

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¹ Example footnote text.

Table 1: Example single column table.

Location		
East Distance	West Distance	Count
100km	200km	422
350km	1000km	1833
600km	1200km	890

2.6 Data Analysis

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3 Results

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Figure 1: Anther of thale cress (*Arabidopsis thaliana*), fluorescence micrograph. Source: Heiti Paves, <https://commons.wikimedia.org/wiki/File:Tolmukapea.jpg>.

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Table 2: *Example two column table with fixed-width columns.*

Location		Count
East Distance	West Distance	
100km	200km	422
350km	1000km	1833
600km	1200km	890

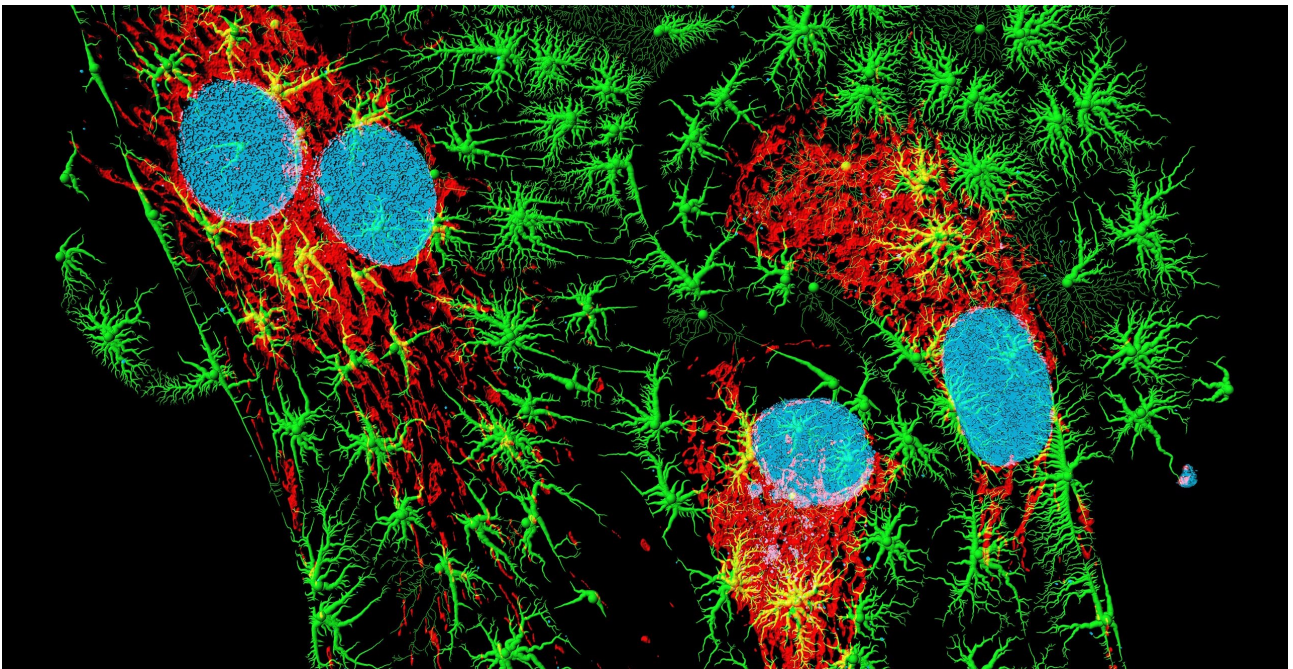


Figure 2: *Bovine pulmonary artery endothelial cells in culture. Blue: nuclei; red: mitochondria; green: microfilaments. Computer generated image from a 3D model based on a confocal laser scanning microscopy using fluorescent marker dyes. Source: Heiti Paves, <https://commons.wikimedia.org/wiki/File:Fibroblastid.jpg>.*

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3.1 International Support

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3.2 Links

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4 Discussion

This statement requires citation [Smith:2023qr]. This statement requires multiple citations [Smith:2023qr, Smith:2024jd]. This statement contains an in-text citation, for directly referring to a citation like so: Smith:2024jd.

4.1 Subsection One

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