

# Incremental Greibach Normal Form (IGNF) Console Tool

## Introduction

The IGNF tool is meant to compare the basic algorithm for constructing the Greibach Normal Form (GNF) to the incremental version by executing them on the same grammar and clocking their run times. There are two implementations of the basic algorithm, one simple version and one version that has been improved by using worklists.

## Installation

1. Untar the package and change to the folder 'IGNF'.
2. Type 'make' to compile the code and link the executable.
3. When successful the executable file named 'ignf' can be found in 'IGNF/bin'.

To compile an executable that displays debug information type 'make debug'.

The corresponding executable is 'ignfD' and can be found in 'IGNF/bin' as well.

Note that the debug version is only meant to be used for very small grammars since every single step the algorithm executes is displayed. Also the clocked run times are not accurate in debug mode,

## Input Format

All algorithms operate on context free string grammars. The incremental algorithm also requires the productions of the grammar being added in a sequence such that the grammar is productive after each added production.

When supplying productions, the first symbol is considered as a nonterminal (context free grammar) which has to be followed by the 'produces' arrow (minus and greater than characters) for better readability. The symbols on the right hand side of the production have to be separated by spaces. Note that symbols on the right hand side that are unknown to the algorithm are automatically considered terminal symbols. In the following example the algorithm has to know an A2 production already or it will consider A2 a terminal symbol.

```
A1 -> A2 b
```

If a grammar is stored in a text file it is possible to define multiple productions of the same nonterminal in the same line by separating the different right hand sides by a pipe.

```
A3 -> b | A3 A4
```

Note that a new line always invalidates the left hand side, which means it is not possible to split multiple right hand sides over multiple lines using the pipe.

## File Mode

The two basic operation modes are 'file mode' and 'console' mode. In file mode the application requires an input file holding a grammar on which both algorithms are run. Afterwards the resulting

grammar in GNF is displayed as well as the run times of both algorithms.

The file mode is invoked by the option -f. There is an input file 'example\_DA.txt' holding a context free string grammar. To execute the tool in file mode on this grammar type

```
./ignf -f example_DA.txt
```

which will generate an output like

```
Final Incremental Algorithm Productions:
A1 -> b@A3c | bc | ab | abA3@A3c | abA3c
A2 -> a
A3 -> b | b@A3 | abA3 | abA3@A3
A4 -> c
@A3 -> c | cA3 | cA3@A3 | c@A3

/-----\
| production | simple | basic | incr. |
|-----|
| A4 -> c    | 0.000042 | 0.000029 | 0.000057 |
| A3 -> b    | 0.000037 | 0.000028 | 0.000038 |
| A3 -> A3A4  | 0.000087 | 0.000080 | 0.000077 |
| A2 -> a    | 0.000085 | 0.000083 | 0.000051 |
| A1 -> A2b   | 0.000101 | 0.000097 | 0.000063 |
| A1 -> A3c   | 0.000172 | 0.000124 | 0.000079 |
| A3 -> A1A3  | 0.000197 | 0.000200 | 0.000137 |
|-----|
| production | simple sum | basic sum | incr. sum |
|-----|
| A4 -> c    | 0.000042 | 0.000029 | 0.000057 |
| A3 -> b    | 0.000079 | 0.000057 | 0.000095 |
| A3 -> A3A4  | 0.000166 | 0.000137 | 0.000172 |
| A2 -> a    | 0.000251 | 0.000220 | 0.000223 |
| A1 -> A2b   | 0.000352 | 0.000317 | 0.000286 |
| A1 -> A3c   | 0.000524 | 0.000441 | 0.000365 |
| A3 -> A1A3  | 0.000721 | 0.000641 | 0.000502 |
\-----/
```

The columns showing the run times are

simple	the time the basic algorithm (simple) takes to construct the GNF of the grammar consisting of the productions added so far
basic	same for the improved version of the basic algorithm
incremental	the time the incremental algorithm takes to incrementally add the current production, restoring the GNF
simple sum	the time the basic algorithm (simple) takes if it has to construct the GNF after each new production, i.e. the sum of the 'basic' column entries
basic sum	same for the improved version of the basic algorithm
incremental sum	the time the incremental algorithm takes to construct the GNF of the grammar consisting of the productions added so far, i.e. the sum of the 'incremental' entries

## Console Mode

The console mode is invoked by the option -c and allows further operations after reading a grammar file as in file mode or starting with an empty grammar by omitting a file name.

```
./ignf -c example_DA.txt
```

This command executes both algorithms on the grammar specified in the file 'example\_DA.txt' and awaits further input. The main feature is to add more productions, but also different properties and statistics can be displayed. Note that only a single production can be added in this way, adding multiple productions by using pipes is not supported.

In the example below the production  $A4 \rightarrow e$  is added to the existing grammar after starting the tool in console mode as above.

```
ignf> A4 -> e
Inserting A4 -> e
Starting basic algorithm (simple version).
Basic algorithm (simple version) terminated successfully.
Starting basic algorithm.
Basic algorithm terminated successfully.
Starting incremental algorithm.
Incremental algorithm terminated successfully.
```

The commands in console mode are

- q quit
- e show encoding table (internal representation of the symbols)
- r show runtime table
- o show original productions (before GNF was constructed)
- s show result of the basic algorithm (simple version)
- b show result of the basic algorithm (improved version)
- i show result of the incremental algorithm

```
ignf> r
/-----\
| production | simple | basic | incr. |
|-----|
| A4 -> c    | 0.000016 | 0.000011 | 0.000023 |
| A3 -> b    | 0.000014 | 0.000011 | 0.000015 |
| A3 -> A3A4 | 0.000043 | 0.000032 | 0.000031 |
| A2 -> a    | 0.000033 | 0.000032 | 0.000020 |
| A1 -> A2b  | 0.000035 | 0.000034 | 0.000022 |
| A1 -> A3c  | 0.000040 | 0.000042 | 0.000027 |
| A3 -> A1A3 | 0.000068 | 0.000069 | 0.000048 |
| A4 -> e    | 0.000224 | 0.000221 | 0.000115 |
|-----|
| production | simple sum | basic sum | incr. sum |
|-----|
| A4 -> c    | 0.000016 | 0.000011 | 0.000023 |
| A3 -> b    | 0.000030 | 0.000022 | 0.000038 |
| A3 -> A3A4 | 0.000073 | 0.000054 | 0.000069 |
| A2 -> a    | 0.000106 | 0.000086 | 0.000089 |
| A1 -> A2b  | 0.000141 | 0.000120 | 0.000111 |
| A1 -> A3c  | 0.000181 | 0.000162 | 0.000138 |
| A3 -> A1A3 | 0.000249 | 0.000231 | 0.000186 |
| A4 -> e    | 0.000473 | 0.000452 | 0.000301 |
\-----/
```

```
Ignf>
```