Automatic and Optimized Communication Grid Generation from Artificial Intelligence Techniques

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M2 MOSIG Research Internship Defense, 28th June 2022

Introduction

Pictogram Grid Communication System (PGCS)

Purpose : Build sequences of pictograms to communicate.

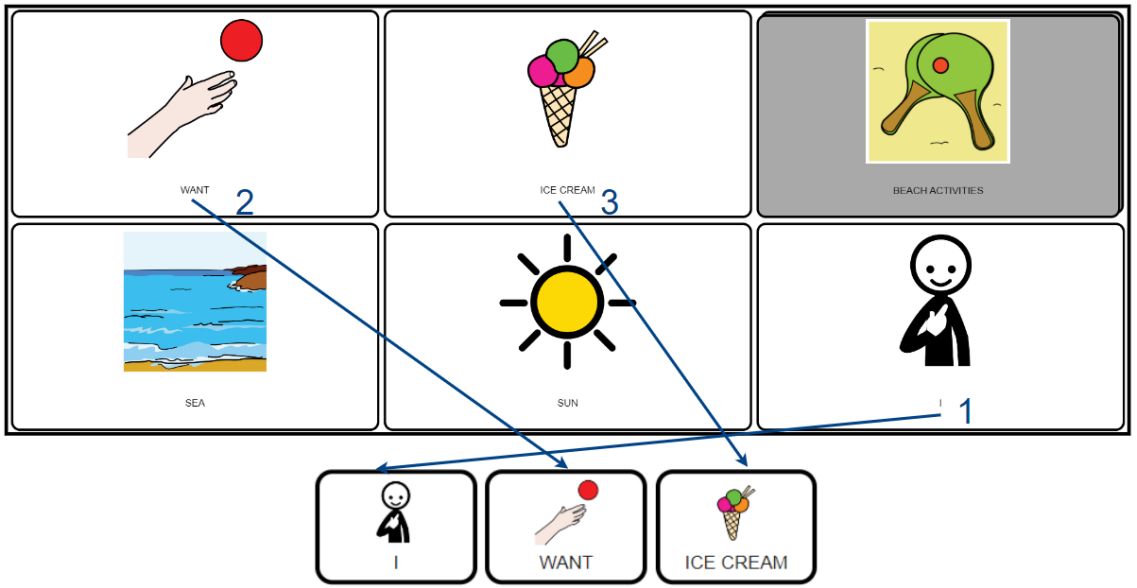


Figure 1: Example of a pictogram grid page.

- Used in AAC (aided system).
- Pictogram grids diversity (size, usage, complexity, etc.)

PGCS : Organization and Displays

- Semantic based
  - Taxonomic display
  - Activity/Contextual display

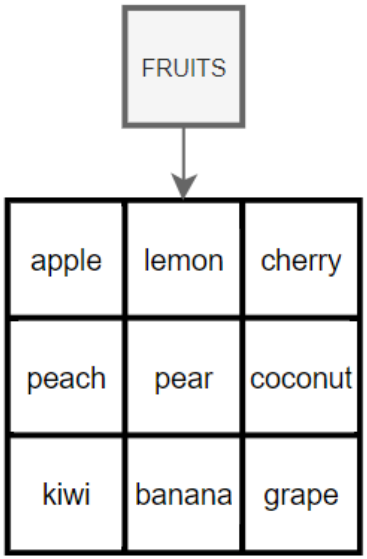


Figure 2: Taxonomic display example.

- Syntactic based

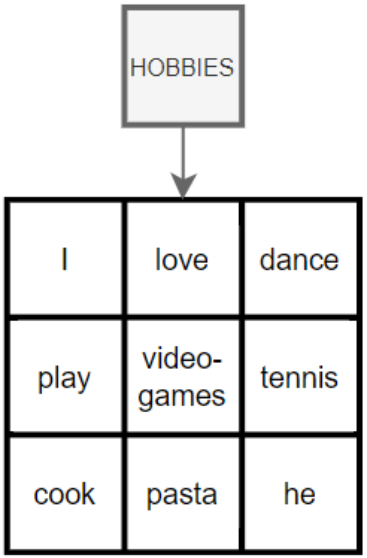


Figure 3: Semantic-Syntactic display example.

Problem Statement

- Manually conceived by Speech-Pathologists.
- Grid Efficiency definition.
- Dependencies : Displays, User, Way of Use.

Optimized Pictogram Grid : Efficient and Satisfy Properties.

Problem :

How to generate an optimized pictogram grid automatically ?

Related Work

Preliminary Works

Grid Efficiency Evaluation (Chasseur *et Al.*, 2020)

- Syntactic information only (distance).
- Build an edge graph for each grid.

Automatic pictogram grid generation with a Genetic Algorithm (Vargas *et Al.*, 2021)

- No mutations.
- Crossover: Blow-up and modify the grid structure.

Genetic Algortihm

- Inspired from Darwin's Evolution Theory.
- **Purpose** : Solving optimization problems.
- Promising results on Pictogram Grid.

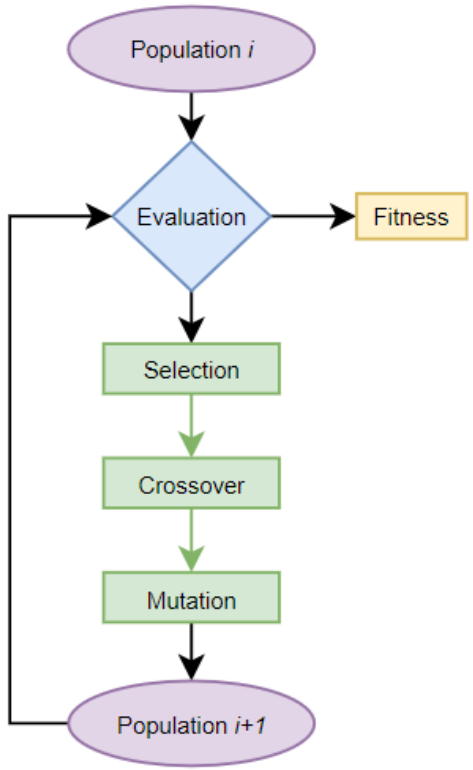


Figure 4: Genetic Algorithm Workflow.

Optimized Pictogram Grid Generation

Grid Structure

- Three elements : Grid, Page, Pictogram
- Page-Tree Structure

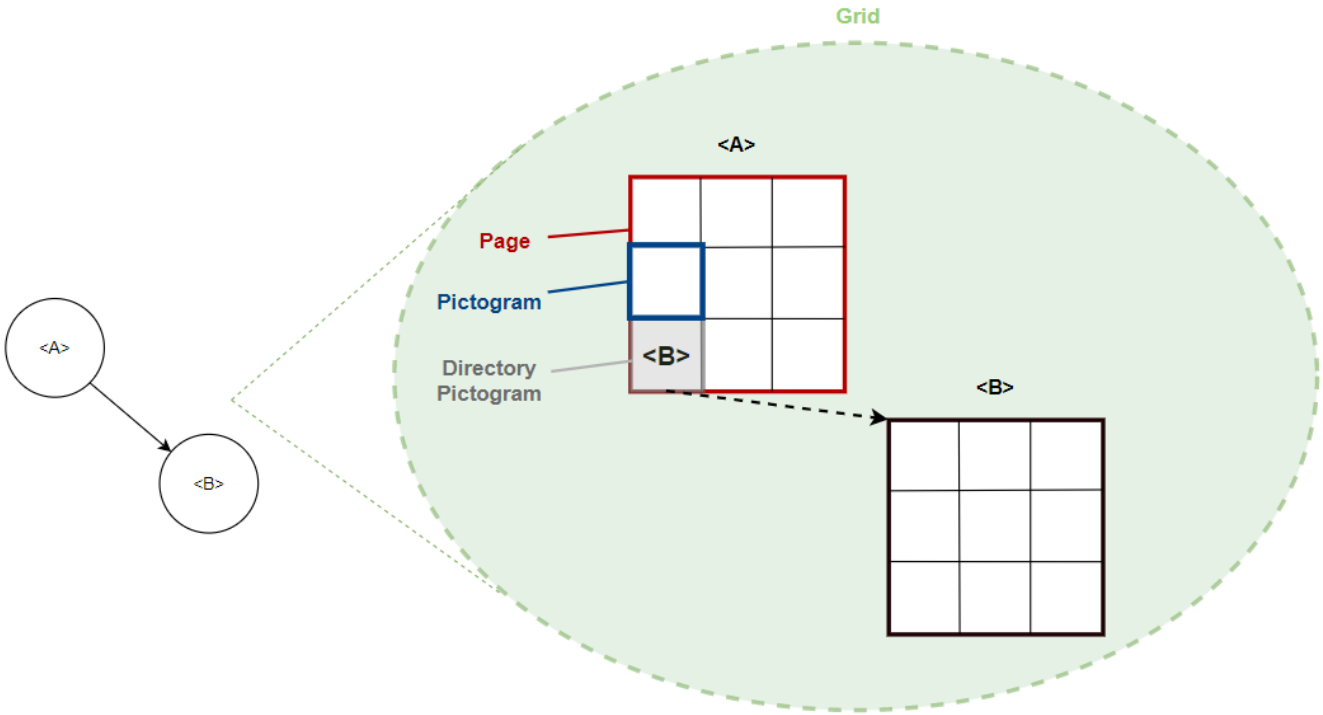
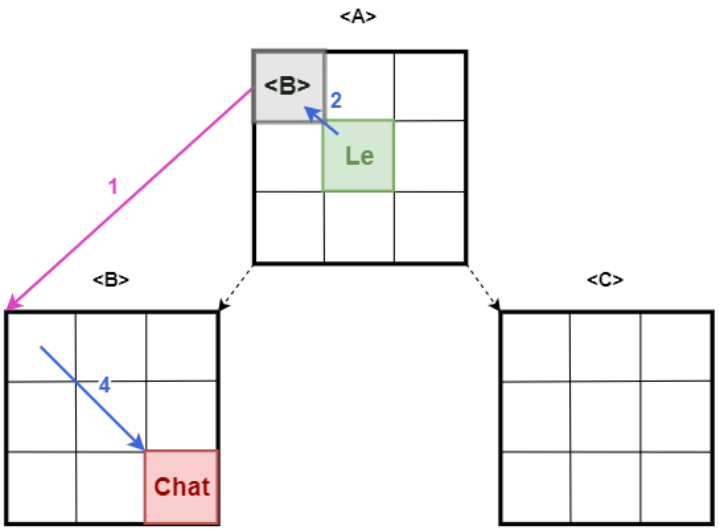


Figure 5: Grid hierarchy and structure.

Hybrid Grid Efficiency Cost

Pictogram Distances



Page Coherence

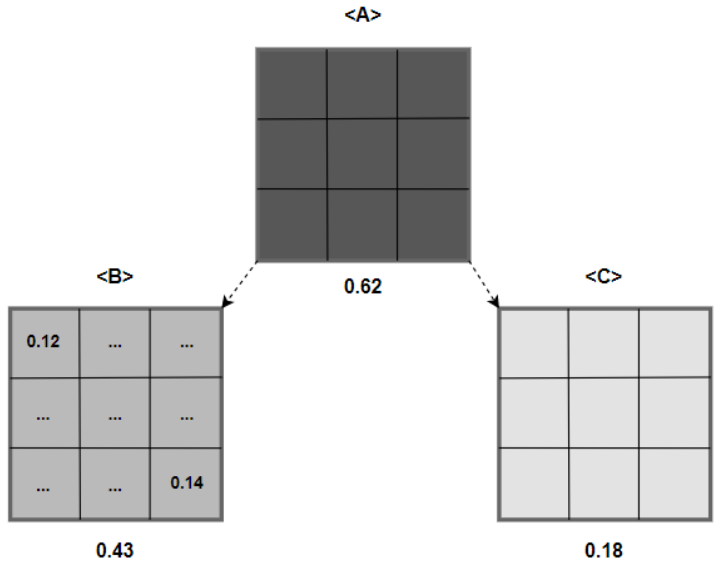


Figure 6: Scheme illustrating the Distance Cost and the Coherence Cost.

Cost of a Grid

$$Cost(G) = log(Cohe(G)) * \alpha \ + log(Dist(G, C)) * (1 - \alpha) \quad (1)$$

Optimized Pictogram Grid Generation Pipeline

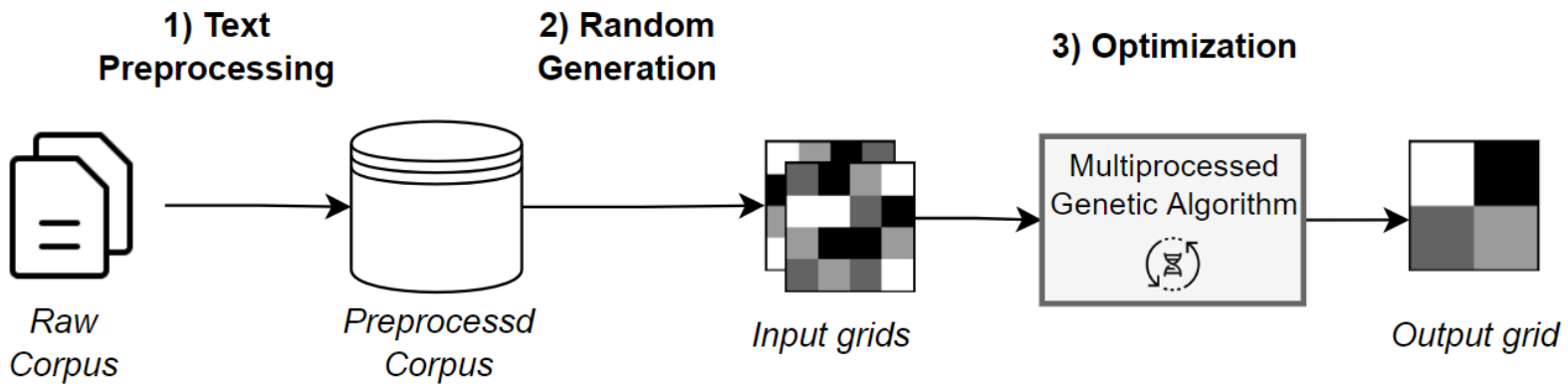


Figure 7: Pictogram Grid Optimization Pipeline.

Genetic Operators : Crossover

Idea : Transmit X and Y pictogram position information to X'.

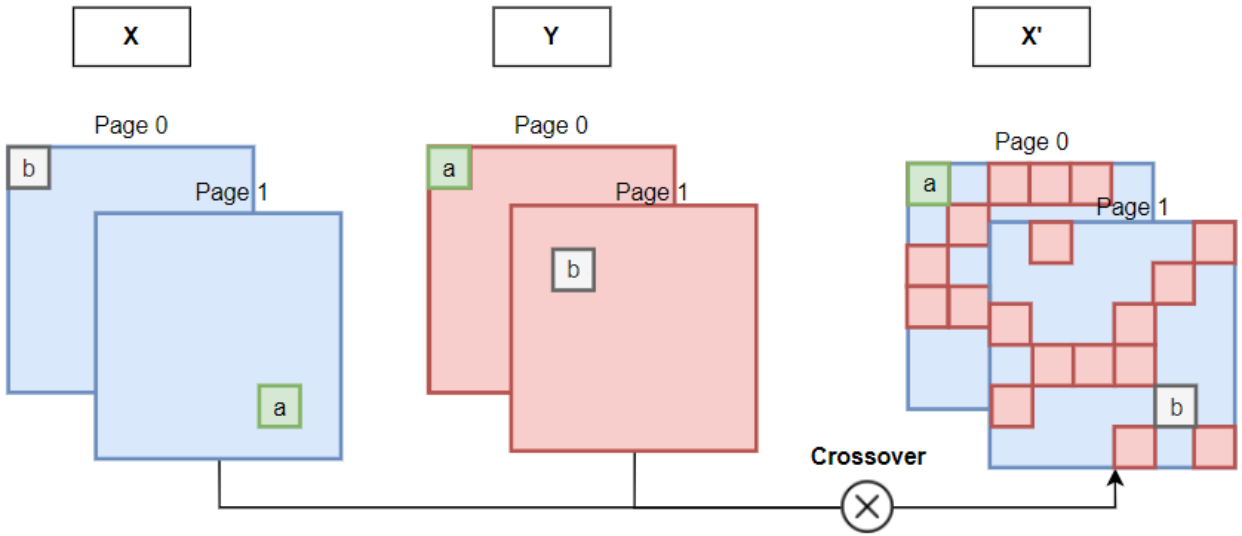
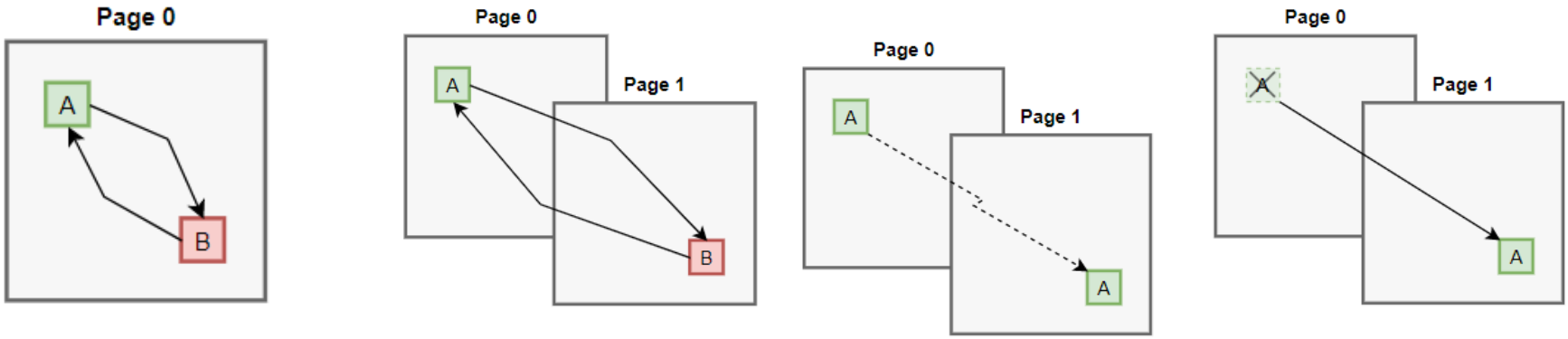


Figure 8: Crossover based on pictogram position.

- Crossover Information Rate : *CRI*

Genetic Operators : Mutations



(a) Swap Intra-Page.

(b) Swap Inter-Page.

(c) Cloning

(d) Displacement

Figure 9: Scheme of the pictogram-based mutations.

- Mutation probabilities : P_{mi}
- Avoid vocabulary loss !

Corpora Dataset

Preprocessing of the Transcriptions

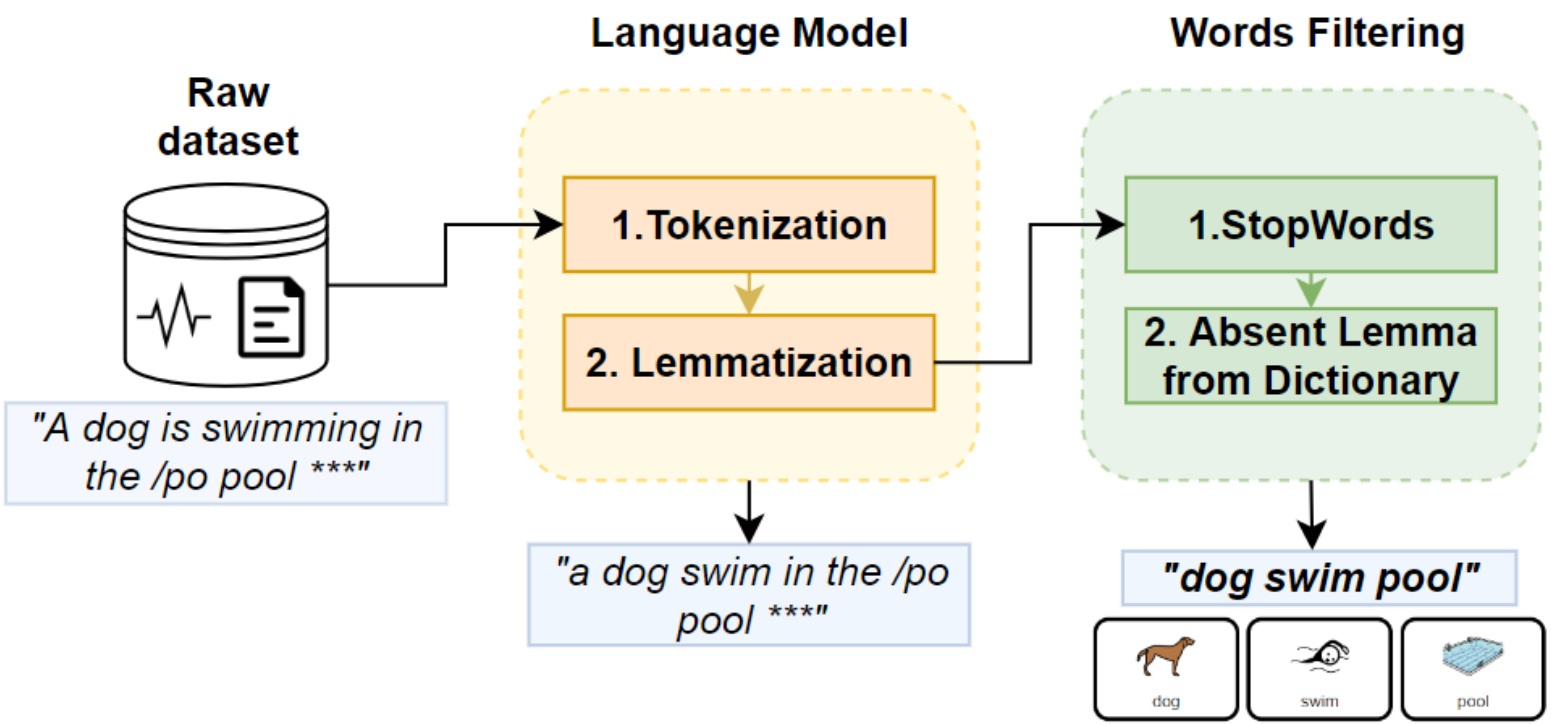


Figure 10: Preprocessing pipeline for raw corpora.

Experiments and Results

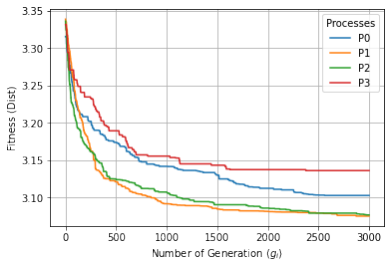
Grid Optimization Experiments

- Two different sized corpora :

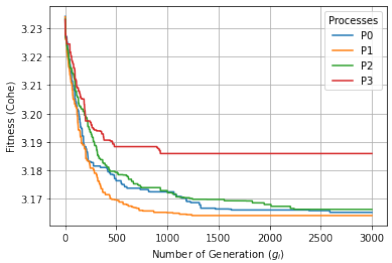
Corpus	Vocabulary Size	Lines
AnimalTexts (AT)	99	49
TCOF Philosophy (Tcof)	2 402	9 635

- Three optimized grid generation :
  - Distance (semantic-syntactic display)
  - Coherence (taxonomic display)
  - Hybrid (contextual display)

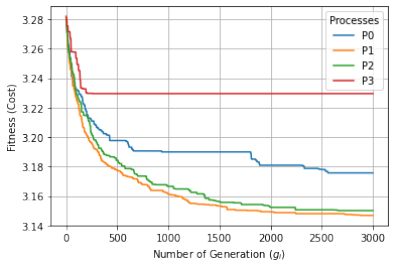
Fitness Convergences



(a) Fitness of AT_{Dist}

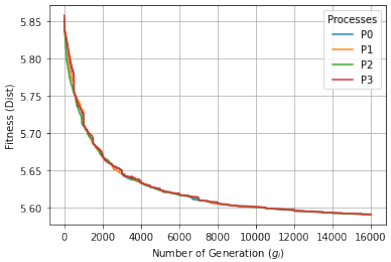


(b) Fitness of AT_{Cohe}

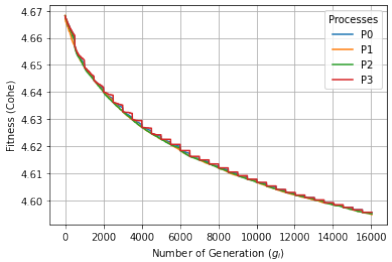


(c) Fitness of AT_{Hybrid}

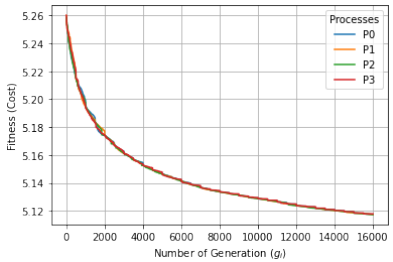
Figure 11: Evolution of the fitness for the AnimalTexts corpus.



(a) Fitness of $Tcof_{Dist}$



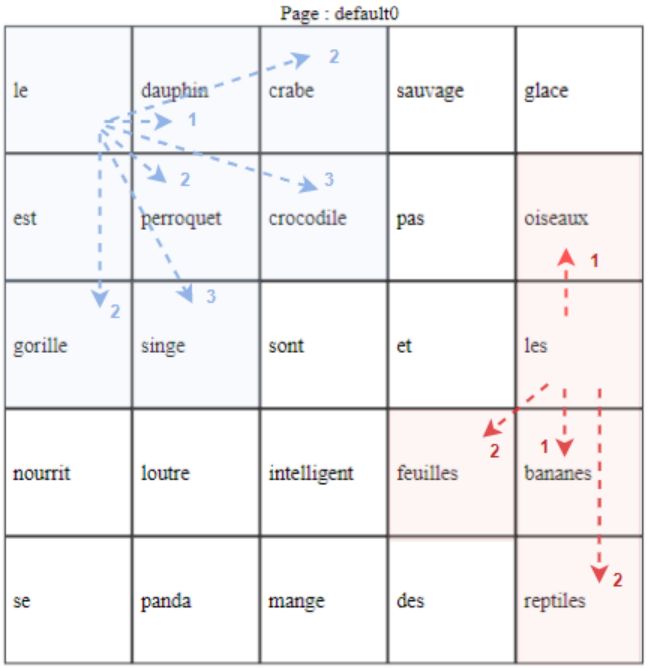
(b) Fitness of $Tcof_{Cohe}$



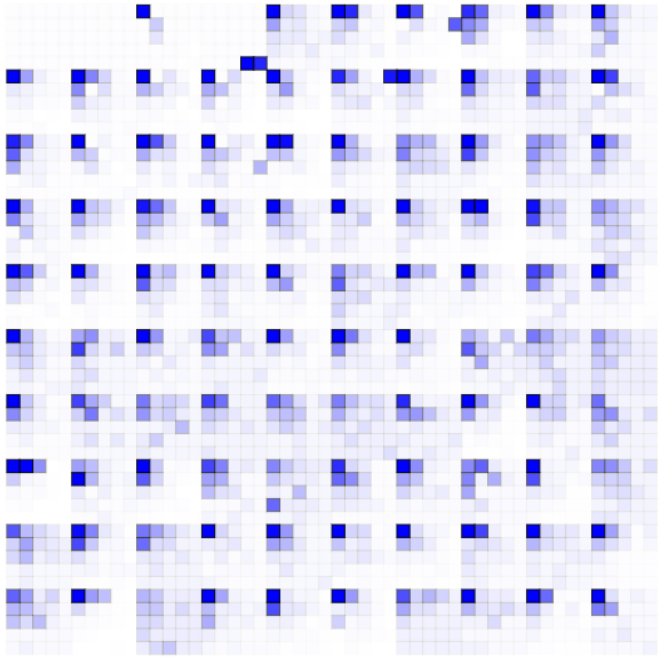
(c) Fitness of $Tcof_{Hybrid}$

Figure 12: Evolution of the fitness for the TCOF corpus.

Distance Optimization



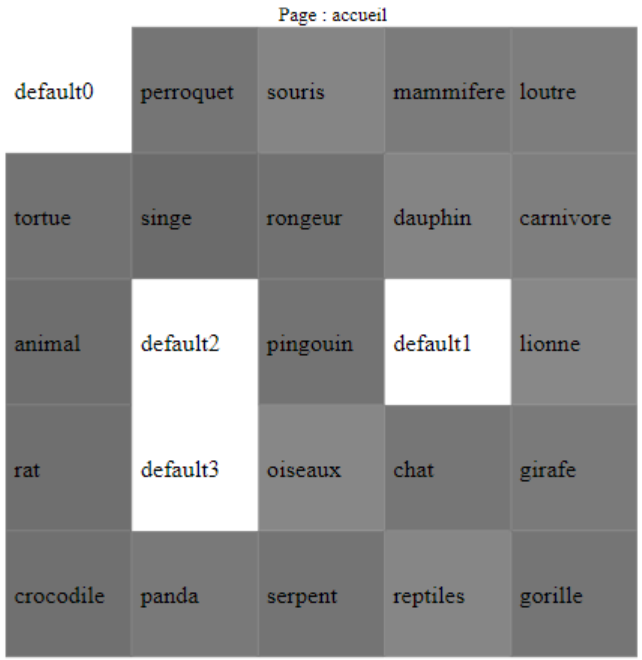
(a) Page "default0" from AT_{Dist}



(b) Heatmap of word occurences from $Tcof_{Dist}$

Figure 13: Results of the optimization with distance experiment.

Coherence Optimization



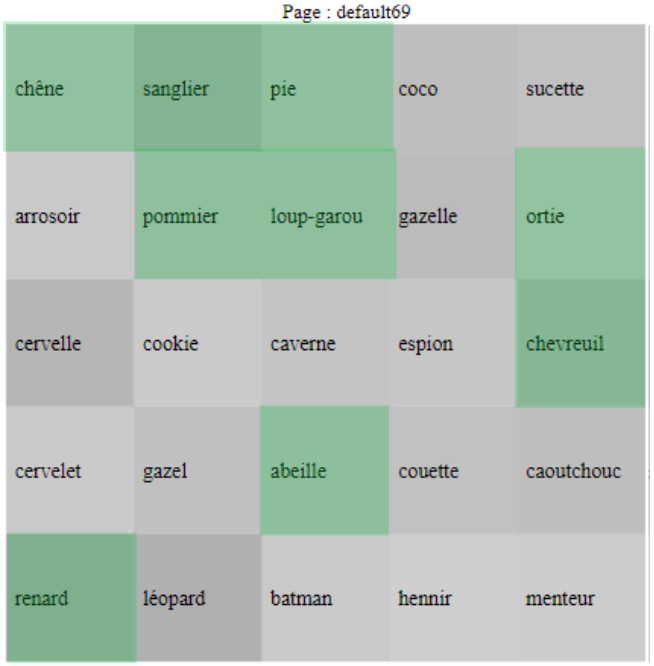
(a) Similarity heatmap of the page "accueil" from AT_{Cohe}

(b) Similarity heatmap of the page "default92" from $Tcof_{Cohe}$

Figure 14: Results of the optimization with coherence experiment.

Hybrid Optimization (1)

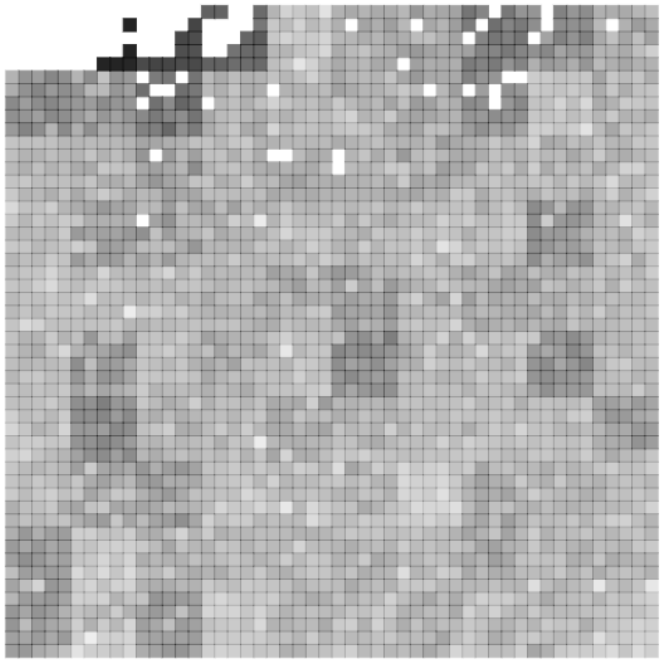
(a) Similarity heatmap of the page "accueil" from AT_{Hybrid}



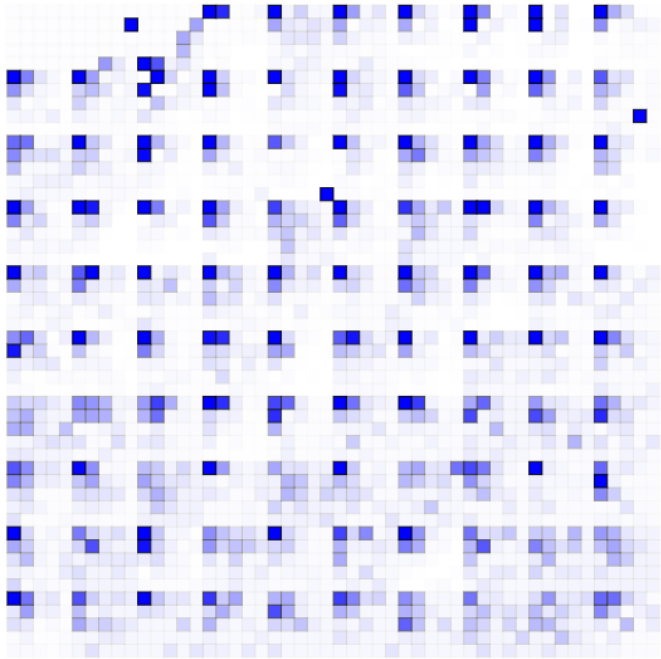
(b) Similarity heatmap of the page "default69" from $Tcof_{Hybrid}$

Figure 15: Results of the optimization with hybrid experiment.

Hybrid Optimization (2)



(a) Global heatmap of similarities from Tcof_{Hybrid}



(b) Heatmap of word occurences from Tcof_{Hybrid}

Figure 16: Results of the optimization with hybrid experiment.

Evaluation with PODD

- Approximative comparison with a French PODD 15.

  $\hookrightarrow$ **Transformation into a page-tree.**

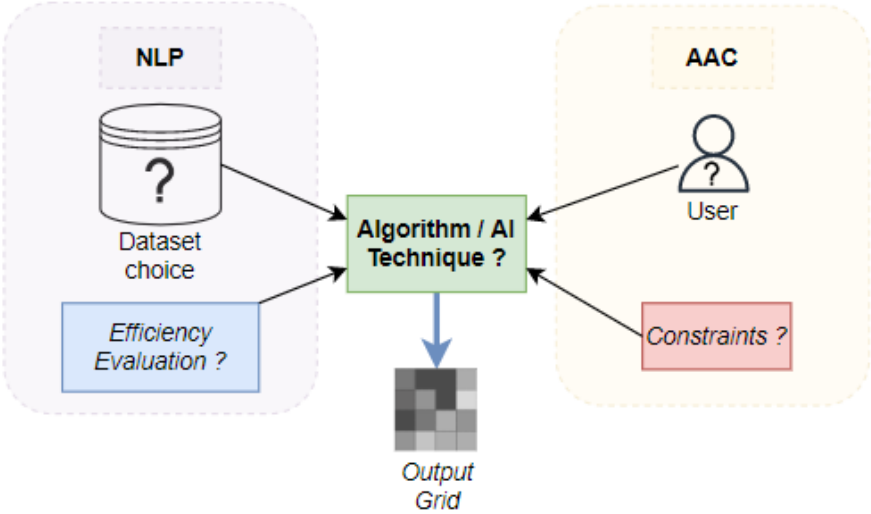
Corpus	$Dist(G)$	$Cohe(G)$	$Cost(G)$
AnimalTexts	AT_{Dist}	AT_{Cohe}	AT_{Hybrid}
TCOF Philosophy	PODD	PODD	$Tcof_{Hybrid}$

- Mismatches due to the dataset quality and complexity.

Conclusion

Conclusion

- Small-scale and Large-scale optimizations.
- Not far from approximate standards.
- Complex problem :



- Requires a user evaluation on the field.

Perspectives

Improvements

- Grid Structure : from Tree to Graph
- Genetic Algorithm :
  - Parallelization.
  - Parameters and Adaptive methods.
- Handle Multilingual resources.
- Starting from Speech (audio signal).

- Alternative : Predictive model.

Aknowledgments

Supervisors : Didier Schwab, Benjamin Lecouteux.

Team GETALP : Gilles Sérasset, Cécile Macaire.

LIG : Renaud Blanch.

References

References

[1] Lucie Chasseur et Al. : *Evaluation of the acceptability and usability of AAC.* , 2020.
[2] Carlos Vargas et Al. : *Automatic generation of communication grids.*, 2021.
[3] Bojanowski et Al. : *fastText : Enriching Word Vectors with Subword Information*, 2016.
[4] Qi et Al : *Stanza: A Python Natural Language Processing Toolkit for Many Human Languages*, 2020.
[5] Pereira et Al : *PictoBERT: Transformers for next pictogram prediction*, 2022.
[6] AugCom platform : *https://lig-augcom.imag.fr/stable//keyboard*.

Appendix

Multiprocessed Genetic Algorithm for PGCS

- Pictogram Grid as an Individual.
- $Cost(G)$, fitness to minimize.

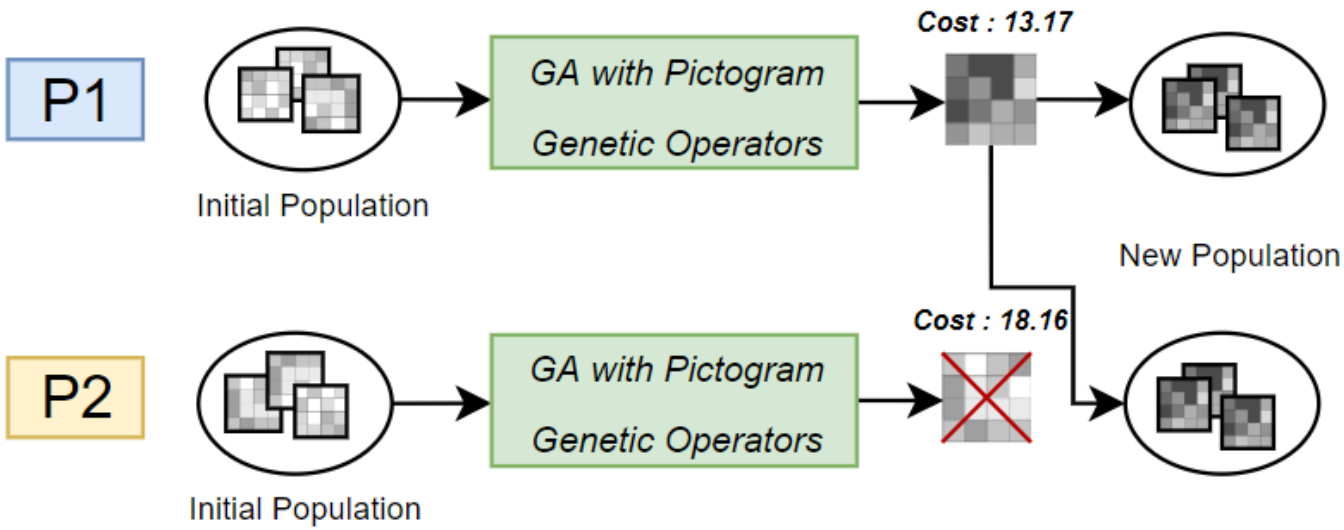


Figure 17: Multiprocessed Genetic Algorithm (GA) for Pictogram Grid.

Language Models

- Similarity Computation → fastText (french) :
  - Vectors of dimension 300.
  - Based on n-grams representation :
    "mangeais" → *"mange"* + *"ais>"*

- Lemmatization → Stanza (French GSD) :
  - Tokenization : Segment the text into tokens (one token per word).
  - Lemmatization : Lemma for each token: *"ate"* → *"eat"*

TCOF Dataset

Traitement de Corpus Oraux en Français (TCOF)

(a)

Adults-Adults			
Adult parts	Speaker changes	Words	Duration (h)
Conferences	1	2 169	0.16
Consultations	1 033	9 020	1
Conversations	23 084	311 084	24
Lectures	443	12 899	1.8
Debates	673	12 613	1
Interviews	9 722	180 487	15.5
Type Not Spec.	333	29 721	2.7
Meetings	11 797	141 602	11
Total	**47 086**	**699 595**	**57.16**

Adults-Child			
Child parts	Speaker changes	Words	Duration (h)
Longitudinal	14 331	128 210	15.3
Transversal	51 600	356 594	43.3
Philosophy	30 060	244 981	19
Total	**95 991**	**729 785**	**77.6**

(b)

Figure 18: Details about the TCOF Dataset and the different parts.

Genetic Algorithm Execution Times

Grids	s/gen	Nb. Generations	Total Time
AT_{Dist}	0.21	3 000	≈13min
AT_{Cohe}	0.13	3 000	≈8min
AT_{Hybrid}	0.19	3 000	≈12min
$Tcof_{Dist}$	27.29	16 000	≈128h
$Tcof_{Cohe}$	3.68	16 000	≈20h
$Tcof_{Hybrid}$	27.56	16 000	≈133h

Figure 19: Execution times from the different experiments.

Results from the Evaluation with the PODD 15

	Grids	Picto/Pages	Costs				
			Dist(G)	$\%\Delta_{Dist}$	$Cohe(G)_{Avg}$	Cost(G)	$\%\Delta_{Cost}$
AT	AT_{Random}	104 / 5	6.31	-48.14	-0.32	1.301	-24.31
	AT_{Dist}	111 / 5	**5.89**	**-66.24**	-0.31	1.210	-38.62
	AT_{Hybrid}	104 / 5	5.92	-64.96	-0.36	**1.208**	**-38.90**
	AT_{Cohe}	104 / 5	6.19	-54.43	**-0.44**	1.246	-33.31
	French_PODD	1 398 / 114	6.97	∅	-0.42	1.422	∅

Figure 20: Evaluation results between PODD and AT grids.

	Grids	Picto/Pages	Costs				
			Dist(G)	$\%\Delta_{Dist}$	$Cohe(G)_{Avg}$	Cost(G)	$\%\Delta_{Cost}$
TCOF	$Tcof_{Random}$	2 482 / 100	12.34	-2.22	-0.28	2.620	+6.17
	$Tcof_{Dist}$	2 500 / 100	11.80	-43.43	-0.27	2.504	-18.72
	$Tcof_{Hybrid}$	2 500 / 100	**11.80**	**-43.73**	-0.33	**2.489**	**-21.48**
	$Tcof_{Cohe}$	2 483 / 100	12.47	+10.19	-0.39	2.625	+7.39
	French_PODD	1 398 / 114	12.37	∅	**-0.42**	2.594	∅

Figure 21: Evaluation results between PODD and TCOF grids.

Page examples from Tcof$_{Hybrid}$

Page : default68

voix	boule	jupe	mani	ba
toilette	os	man	dentiste	ga
console	mince	isa	janvier	pe
mi	éclair	catherine	d	rêtre
i	ré	ongle	tom	paille

(a) Page "default68" from Tcof$_{Hybrid}$

Page : default39

raison	gêner	déconseiller	rater	chatouiller
enlever	sauver	taire	couiner	déformer
recommencer	casser	inquiéter	allumer	redoubler
tentation	entrainer	survolter	manquer	bagarrer
chanter	patience	concours	stresser	grogner

(b) Page "default39" from Tcof$_{Hybrid}$

Figure 22: Example of coherence contrast between two pages.

PictoBERT in a Nutshell

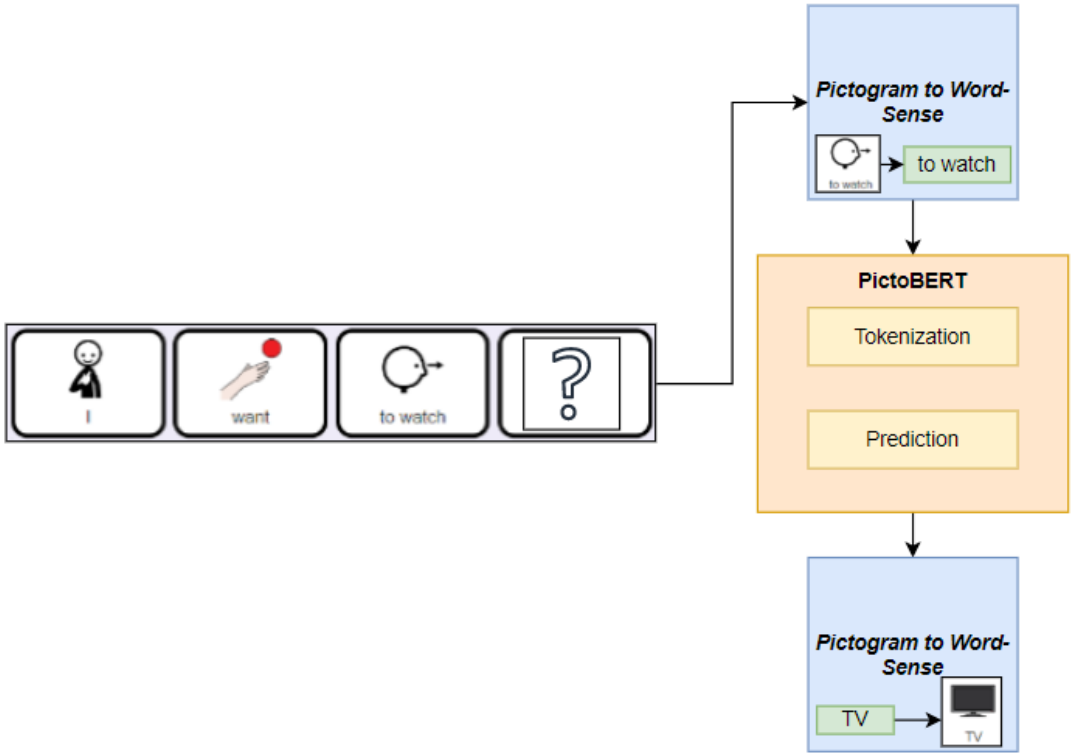


Figure 23: Workflow of PictoBERT.

Visualization Tool PictoGriz

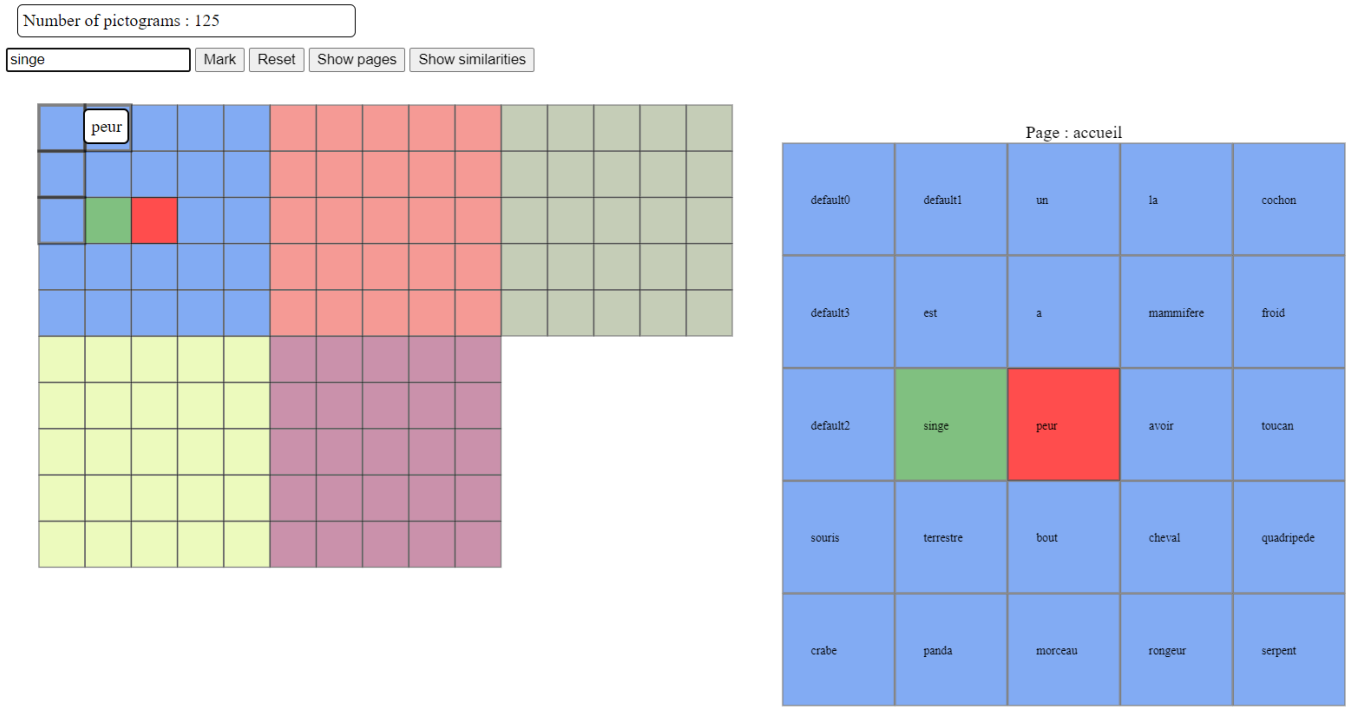


Figure 24: Screenshot of PictoGriz.

Genetic Algortihm (2)

Problem : Maximizing the number of chromosome colors of each individual.

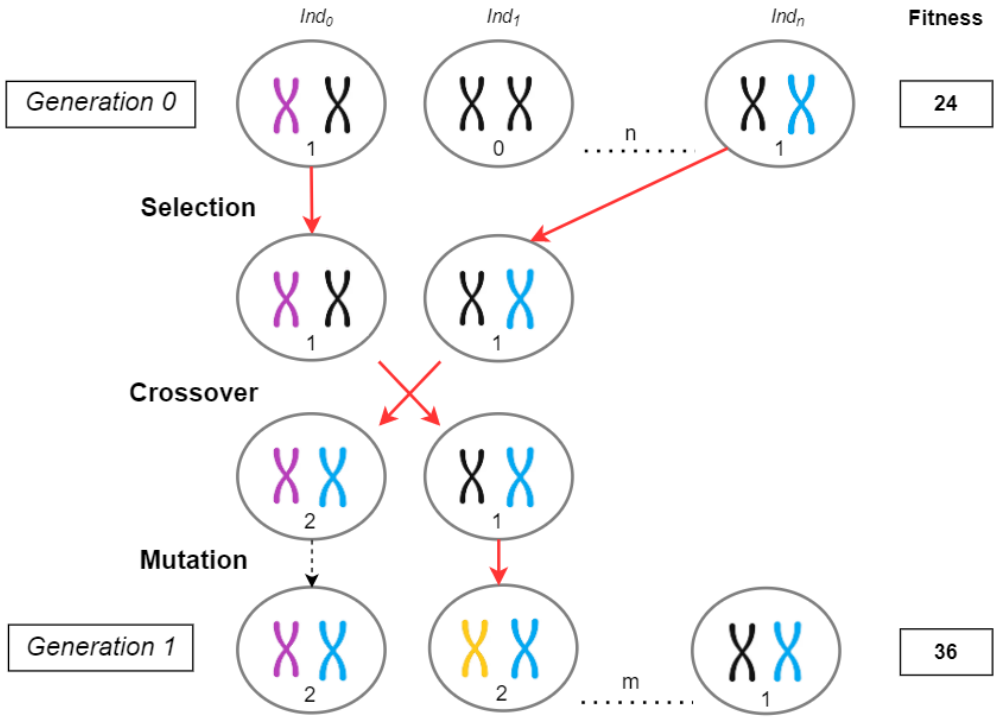


Figure 25: Elemental example of a genetic algorithm step