Benchmarking Memetic Feature Selection

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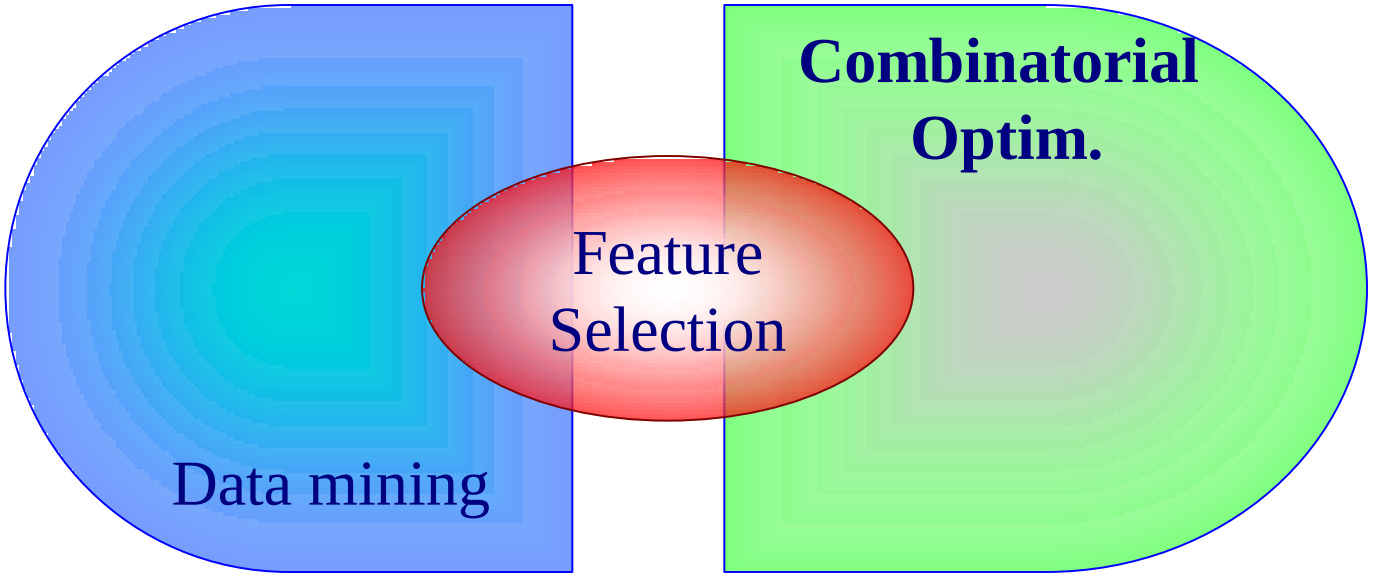
HAIS-2010

Outline

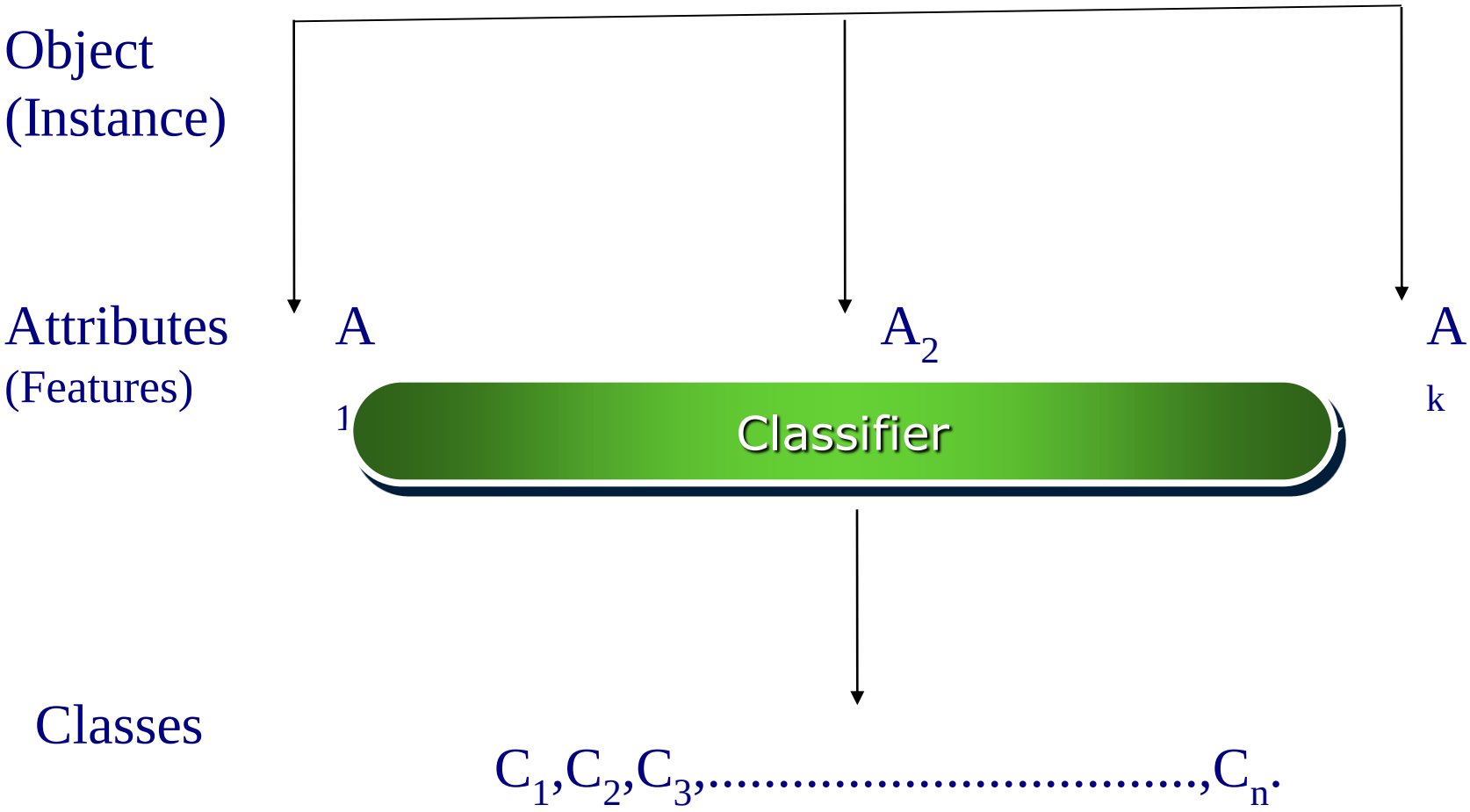
1. Introduction
2. Feature Selection
3. Proposed approach
4. Conclusion and persp.

Introduction



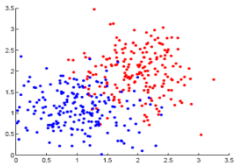
What are the best inputs that can improve classification accuracy ?

Classification



Feature Selection (FS)

Expert



Context

Q

How to select the more representative Features?

All → Select → Noisy, irrelevant, redundant

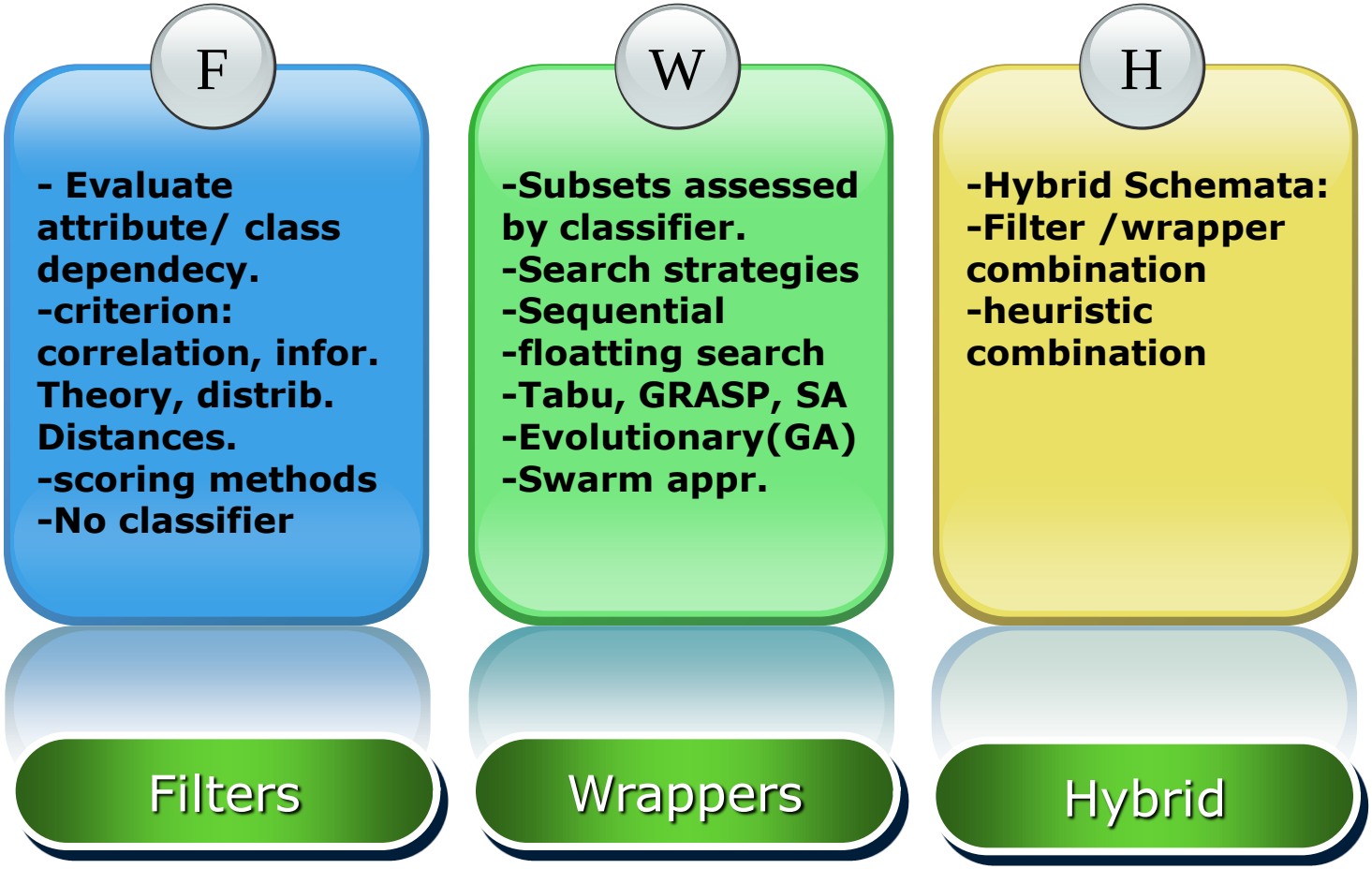
few → discard → Relevant

R

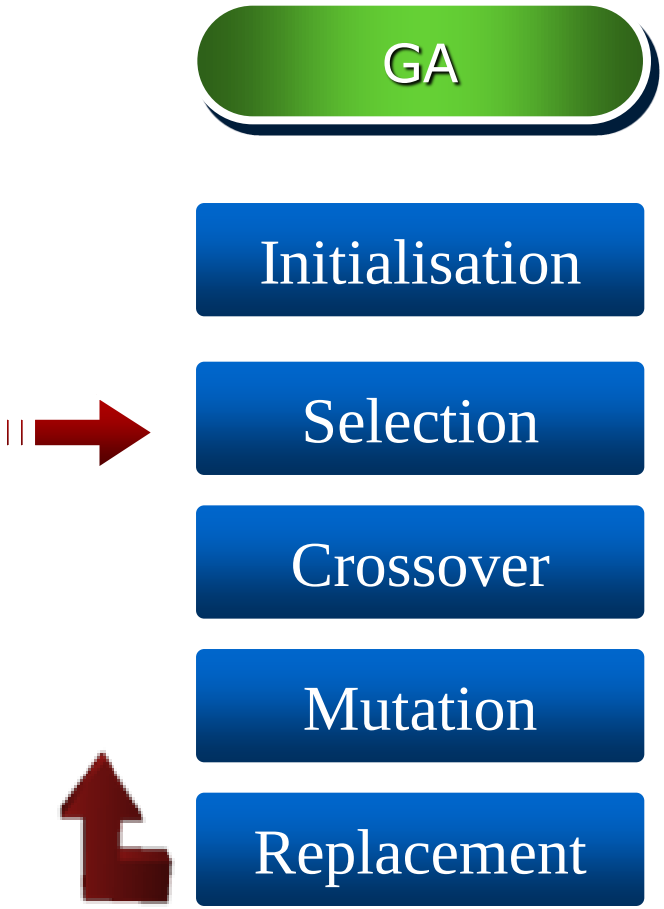
Exploring a search space of 2^n subsets?

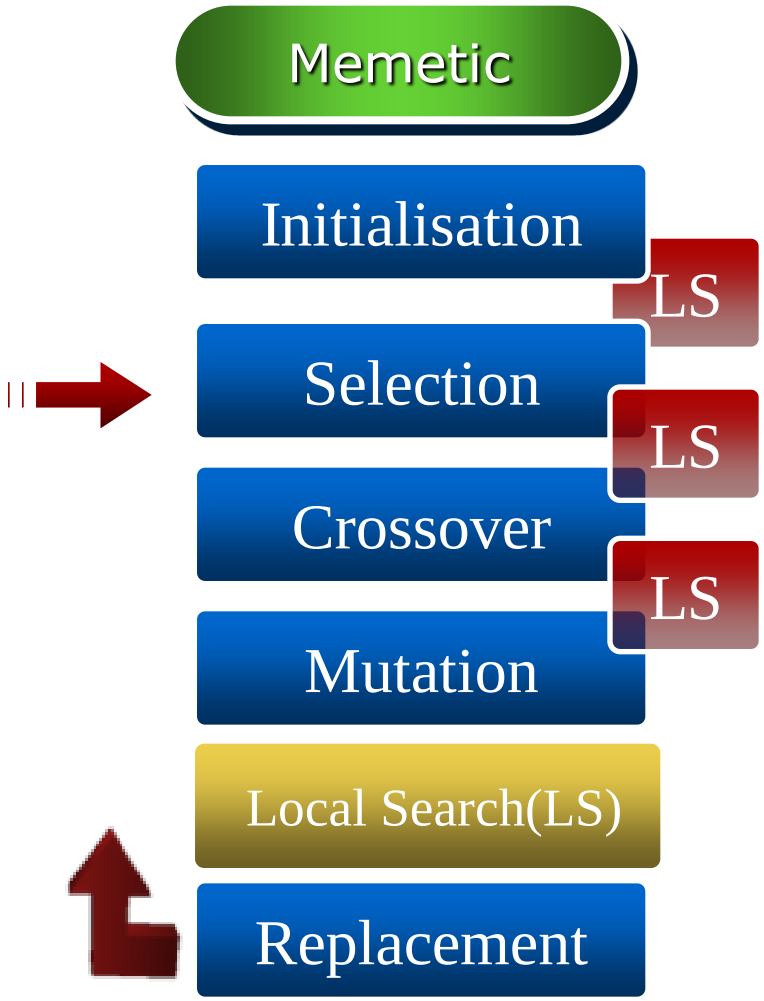
Combinatorial nature of the FS problem

Existing Approaches



GA vs Memetic Algorithms



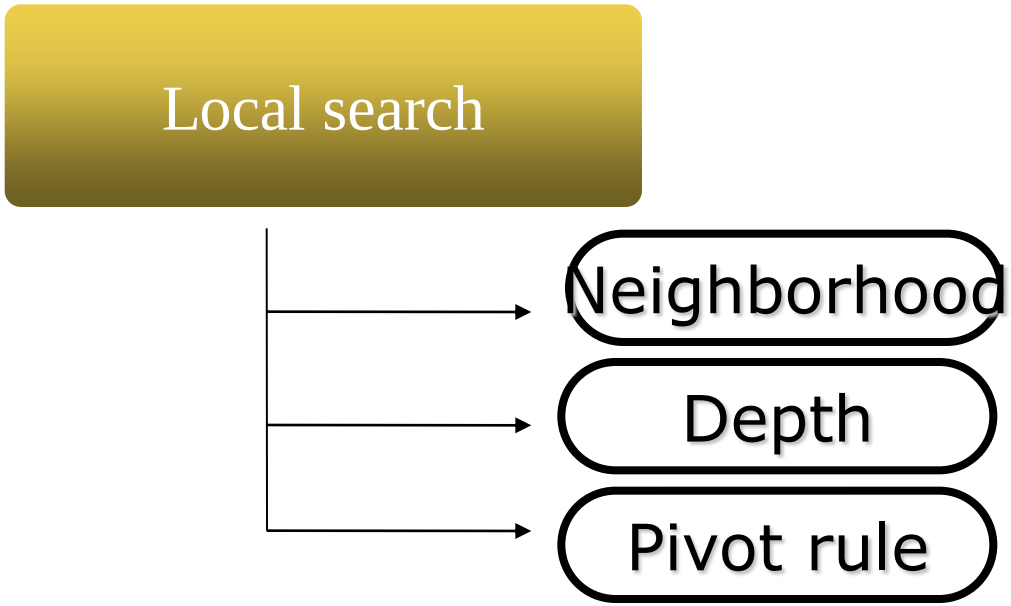


Why memetic search?

- Enhancing GA capabilities:
  - **exploration**: evolutionary Operators
  - **intensification**: Local search
- LS refines new solutions: exchanging them by improved ones.
- LS: ability to implement a specific problem Knowledge (meme).
  - Neigborgood exploration
- Numerous integration alternatives.
- Successful application of GA in FS modeling

Local Search

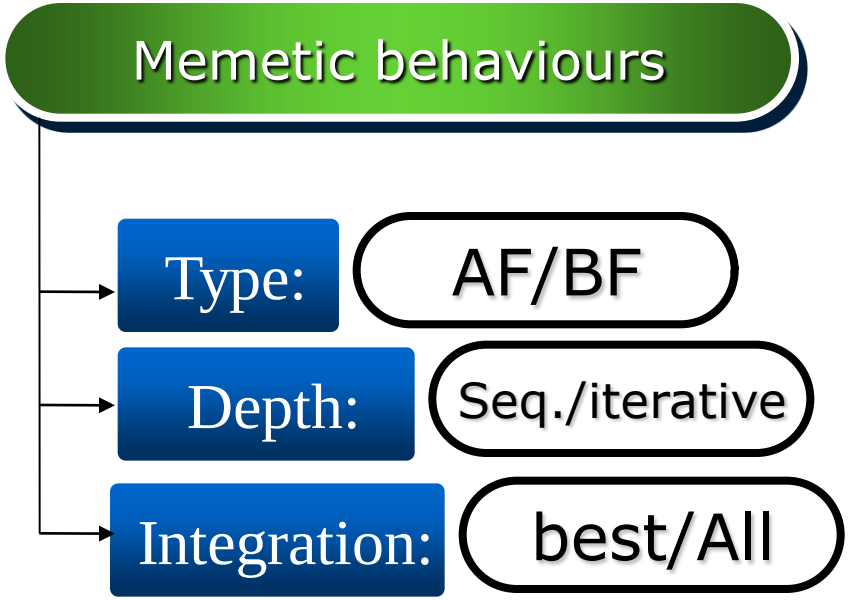
- **Idea**: improve the current solution by exploring its neighborhood



Proposed memetic Schemata

BitFlip:BF
-Add /remove a feature at a time
-Hamming distance= 1

Attrib. flip
- Replace an attribute by another attribute



Q **What is the more effective schema?**

Solution: binary representation
(0/1) Selected / Not selected

Experiments

- Data sets: 3 UCI benchmarks
  - Dimensions: [57..2000]
- Evaluation criterion:
  - Error rate(%)
  - Test methods: Hold out(Search), CV(validation)
- Experiments:
  - Run at least 10 times.
  - Reported results: Mean; St. Dev, *t*-Test

Results

		SpamBase		Arrhythmia		Colon cancer		
		Gain	Rank	Gain	Rank	Gain	Rank	
Seq.	BF(Best)	8,37%	8	1,93%	8	31,60%	4	
	AF(Best)	26,18%	3	9,45%	3	28,83%	5	
	BF(All)	12,12%	6	3,97%	6	26,69%	6	
	AF(All)	38,30%	2	13,89%	2	44,94%	2	
Iter.	BF(Best)	9,44%	7	1,98%	7	14,42%	7	
	AF(Best)	24,79%	4	6,48%	4	33,28%	3	
	BF(All)	14,91%	5	4,96%	5	13,34%	8	
	AF(All)	40,77%	1	17,21%	1	56,6%	1	

Results(2)

1

Global improvement

-All memetic schema enhances GA

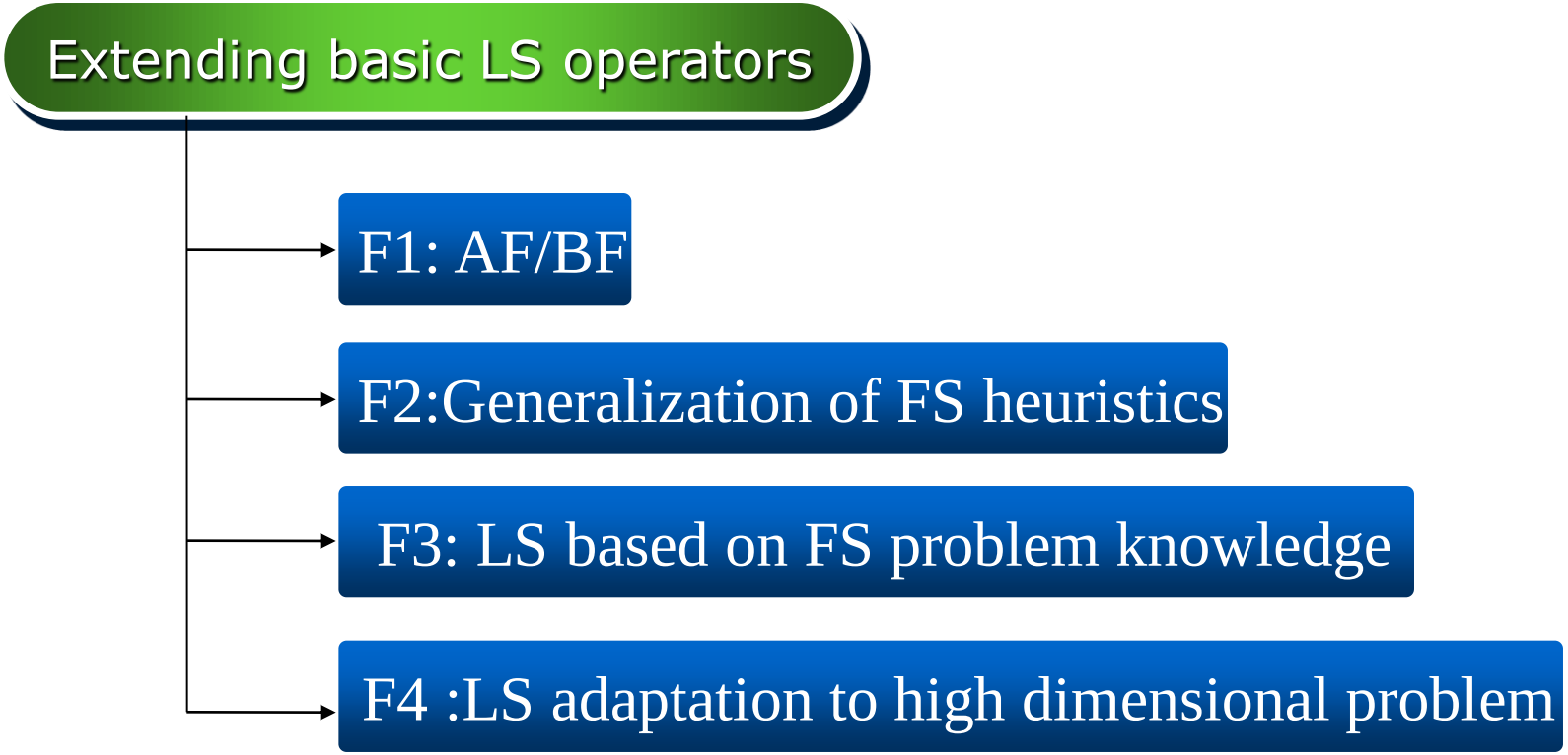
2

AF vs BF
-Suepriority of AF schema over BF
-Top 3

3

-Some sequential schemata outpermors iterative LS
-search improvements for large problem dimensionalities

Current Work



Conclusion

- FS problem is a multi-disciplinary reseach field,

and the combinatorial issue stills one of the more attractive.

- We investigate 8 memetic schemata.
  - Global improvement over GA
  - Some schemata are more intersting.
- Hybrid modeling is an effective way to tackle FS problems.

Perspectives

- Investigation of new Neighborhood structures.
- Study behavioral aspects of LS with differnt meta-heuristics
- Adaptation and application to high dimensional problems.
  - (Gene expression data).
  - Proteomics

Thank You !

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Questions?

Remarks!

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				VALIDATION ERROR%						
LS applied to GA		Measures	Fitness	ANN	NB	CPU (s)	# Attrib.	# Eval	Gain%GA	RANK
No LS (GA)		Mean:	9,32%	10,74%	7,81%	14774,13	15,04	1089		
		Sd:	0,95%	1,45%	1,10%	14759,99	3,15	0		
		t-test	0	0	0	0	0	-		
SEQ	BitFlip(Best)	Mean:	8,54%	11,10%	8,24%	35672,26	13,87	3089	8,37%	8
		Sd:	1,02%	2,04%	1,27%	36614,23	2,94	0	-	
		t-test	-18,92	3,71	4,95	22,08	-12,67	-	-	
	AttribFlip(Best)	Mean:	6,88%	9,61%	7,26%	32705,52	15,96	3089	26,18%	3
		Sd:	1,15%	2,25%	1,49%	28955,4	4,88	0	-	
		t-test	-37,43	-8,41	-5,85	18,74	5,31	-	-	
	BitFlip(all)	Mean:	8,19%	10,58%	8,23%	91471,7	15,45	11289	12,12%	6
		Sd:	0,98%	1,98%	1,50%	40881,06	3,2	0	-	
		t-test	-29,95	-1,7	7,22	31,64	1,49	-	-	
	AttribFlip(all)	Mean:	5,75%	8,95%	6,73%	95083,75	17,6	11289	38,30%	2
		Sd:	0,69%	1,93%	1,50%	45427,35	4,47	0	-	
		t-test	-73,7	-10,69	-23,21	44,9	85,05	-	-	
Iterative	BitFlip(Best)	Mean:	8,44%	9,98%	7,49%	36313,91	15,61	3171,17	9,44%	7
		Sd:	1,17%	1,75%	1,56%	34137,85	4,38	32,04	-	
		t-test	-20,55	-6,81	-4,72	54,25	8,08	-	-	
	AttribFlip(Best)	Mean:	7,01%	9,62%	7,27%	35944,87	14,87	3209,43	24,79%	4
		Sd:	1,01%	2,10%	1,44%	38229,41	3,63	33,37	-	
		t-test	-45,78	-11,65	-9,22	23,64	-3,54	-	-	
	BitFlip(all)	Mean:	7,93%	10,35%	7,70%	128806,75	15,35	14180,5	14,91%	5
		Sd:	0,93%	1,50%	1,18%	112289,05	3,1	418,7	-	
		t-test	-54,13	-3,5	-2,06	55,51	2,61	-	-	
	AttribFlip(all)	Mean:	5,52%	7,69%	6,30%	106967,85	17,6	12911	40,77%	1
		Sd:	0,49%	1,22%	1,31%	49985,26	2,91	137,52	-	
		t-test	-151,28	-31,84	-22,96	51,35	85,05	-	-	

Table 2. Data set: SpamBase (57 Attrib.)

				VALIDATION ERROR%						
LS applied to GA		Measures	Fitness	ANN	NB	CPU (s)	# Attrib.	# Eval	Gain%GA	RANK
No LS (GA)		Mean:	6,52%	6,58%	12,19%	31079,73	23,18	3032		
		Sd:	2,92%	3,14%	4,41%	22980,17	7,45	0		
		t-test	0	0	0	0	0	-		
SEQ	BitFlip(Best)	Mean:	4,46%	6,28%	10,32%	38454,95	20,55	5032	31,60%	4
		Sd:	2,05%	2,97%	4,59%	30297,6	6,6	0	-	
		t-test	-20,87	-2,11	-7,8	5,73	-5,45	-	-	
	AttribFlip(Best)	Mean:	4,64%	7,06%	10,06%	41058,14	21,41	5032	28,83%	5
		Sd:	2,25%	2,96%	3,23%	37162,49	8,55	0	-	
		t-test	-14,38	5,19	-15,01	7,69	-4,35	-	-	
	BitFlip(all)	Mean:	4,78%	5,96%	11,49%	200004,95	22,05	13232	26,69%	6
		Sd:	2,96%	2,98%	2,96%	102160,5	6,34	0	-	
		t-test	-17,19	-5,06	-4,23	22,81	-3,15	-	-	
	AttribFlip(all)	Mean:	3,59%	5,74%	11,49%	198320,55	22,05	13232	44,94%	2
		Sd:	1,62%	2,59%	3,12%	102691,3	6,78	0	-	
		t-test	-24,16	-4,14	-8,47	40,91	-3,15	-	-	
Iterative	BitFlip(Best)	Mean:	5,58%	6,29%	11,47%	39703,43	20,91	5073,74	14,42%	7
		Sd:	2,25%	3,17%	4,39%	30596,31	7,36	30,84	-	
		t-test	-5,31	-1,42	-1,37	12,2	-3,23	-	-	
	AttribFlip(Best)	Mean:	4,35%	6,94%	11,84%	39066,78	20,09	5068,09	33,28%	3
		Sd:	2,17%	2,81%	3,44%	31127,5	6,31	10,33	-	
		t-test	-15,9	2,48	-3,93	6,94	-6,98	-	-	
	BitFlip(all)	Mean:	5,65%	7,02%	11,38%	249361,3	18,45	15199,5	13,34%	8
		Sd:	2,86%	3,59%	3,86%	142791,7	6,51	711,49	-	
		t-test	-4,35	1,71	-5,02	57,21	-12,59	-	-	
	AttribFlip(all)	Mean:	2,83%	6,28%	9,89%	213912,1	20,2	13790	56,60%	1
		Sd:	1,88%	3,27%	3,86%	122469,18	7,03	66,38	-	
		t-test	-21,43	-1,33	-23,24	29,99	-6,06	-	-	

Table 3. Data set: Colon cancer (2000 Attrib.)

				VALIDATION ERROR%						
LS applied to GA		Measures	Fitness	ANN	NB	CPU (s)	# Attrib.	# Eval	Gain%GA	RANK
No LS (GA)		Mean:	17,14%	13,38%	17,33%	158683,53	85,79	1311		
		Sd:	0,90%	1,13%	1,31%	72380,76	17,63	0		
		t-test	0	0	0	0	0	-		
SEQ	BitFlip(Best)	Mean:	16,81%	13,86%	17,09%	490897,85	93,7	3311	1,93%	8
		Sd:	0,91%	1,11%	1,30%	222623,21	14,37	0	-	
		t-test	-23,47	6,69	-2	26,47	11,23	-	-	
	AttribFlip(Best)	Mean:	15,52%	14,03%	17,29%	519275,2	92,25	3311	9,45%	3
		Sd:	1,08%	1,67%	1,59%	347110,37	46,42	0	-	
		t-test	-65,25	2,69	-0,42	17,8	2,1	-	-	
	BitFlip(all)	Mean:	16,46%	14,02%	17,36%	1785624,68	82,74	11511	3,97%	6
		Sd:	1,24%	1,91%	1,75%	898120,57	20,56	0	-	
		t-test	-36,87	7,77	0,22	37,76	-3,46	-	-	
	AttribFlip(all)	Mean:	14,76%	14,22%	16,83%	1892140,75	89,4	11511	13,89%	2
		Sd:	0,80%	2,25%	1,30%	1141857,26	42,76	0	-	
		t-test	-71,41	7,94	-5,5	33,02	11,46	-	-	
Iterative	BitFlip(Best)	Mean:	16,80%	14,40%	16,59%	525793,95	91,2	3516	1,98%	7
		Sd:	0,91%	1,50%	1,67%	290212,63	26,49	55,2	-	
		t-test	-16,38	11,1	-8,17	43,48	5,22	-	-	
	AttribFlip(Best)	Mean:	16,03%	14,16%	16,76%	468881,85	93,9	3512,5	6,48%	4
		Sd:	1,03%	1,78%	1,87%	315436,97	56,97	40,3	-	
		t-test	-26,71	5,14	-6,36	28,42	1,19	-	-	
	BitFlip(all)	Mean:	16,29%	13,79%	16,67%	2591560,62	83,1	15471,95	4,96%	5
		Sd:	1,15%	1,50%	1,52%	1343356,45	22,25	600,1		
		t-test	-24,61	5,56	-7,31	51,56	-8,75	-	-	
	AttribFlip(all)	Mean:	14,19%	14,91%	16,61%	1384673,95	51,65	13731,5	17,21%	1
		Sd:	0,92%	1,30%	1,38%	763942,71	32,57	272,29	-	
		t-test	-138,18	20,26	-7,89	172,14	-11,26	-	-	

Table 4. Data set: Arrhythmia (279 Attrib.)

LS-Operator		Order of Complexity	Parameters
SEQ	BitFlip(Best)	$\Theta(N)$	N: number of features m : mating pool size
	AttribFlip(Best)	$\Theta(N^2)$	
	BitFlip(all)	$\Theta(N.m)$	
	AttribFlip(all)	$\Theta(N^2.m)$	
Iterative	BitFlip(Best)	$\Theta(N.d)$	d: local search depth
	AttribFlip(Best)	$\Theta(N^2.d)$	
	BitFlip(all)	$\Theta(N.m.d)$	
	AttribFlip(all)	$\Theta(N^2.m.d)$	

Table 1. Complexity of local search operators


LOG
O


LOG
O

Diagram

1

-Boost existing FS approaches
-explore new strategies (ACO - PSO)

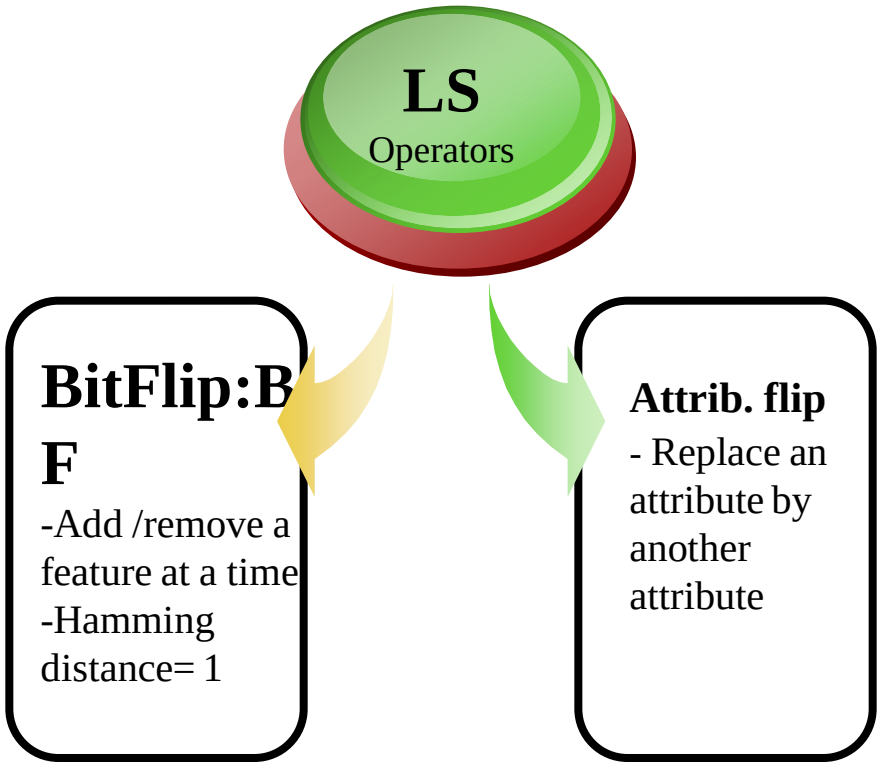
2

-Distributed version
Of retained model
-study dynamics and collaboration behavior

3

-Optimize Embedded Strategies
PSO/ACO
SVM-RF

Proposed memetic Schemata



Memetic behaviours

Type:

Application

Integration:

Solution: binary representation
(0/1) Selected / Not selected

Research directions

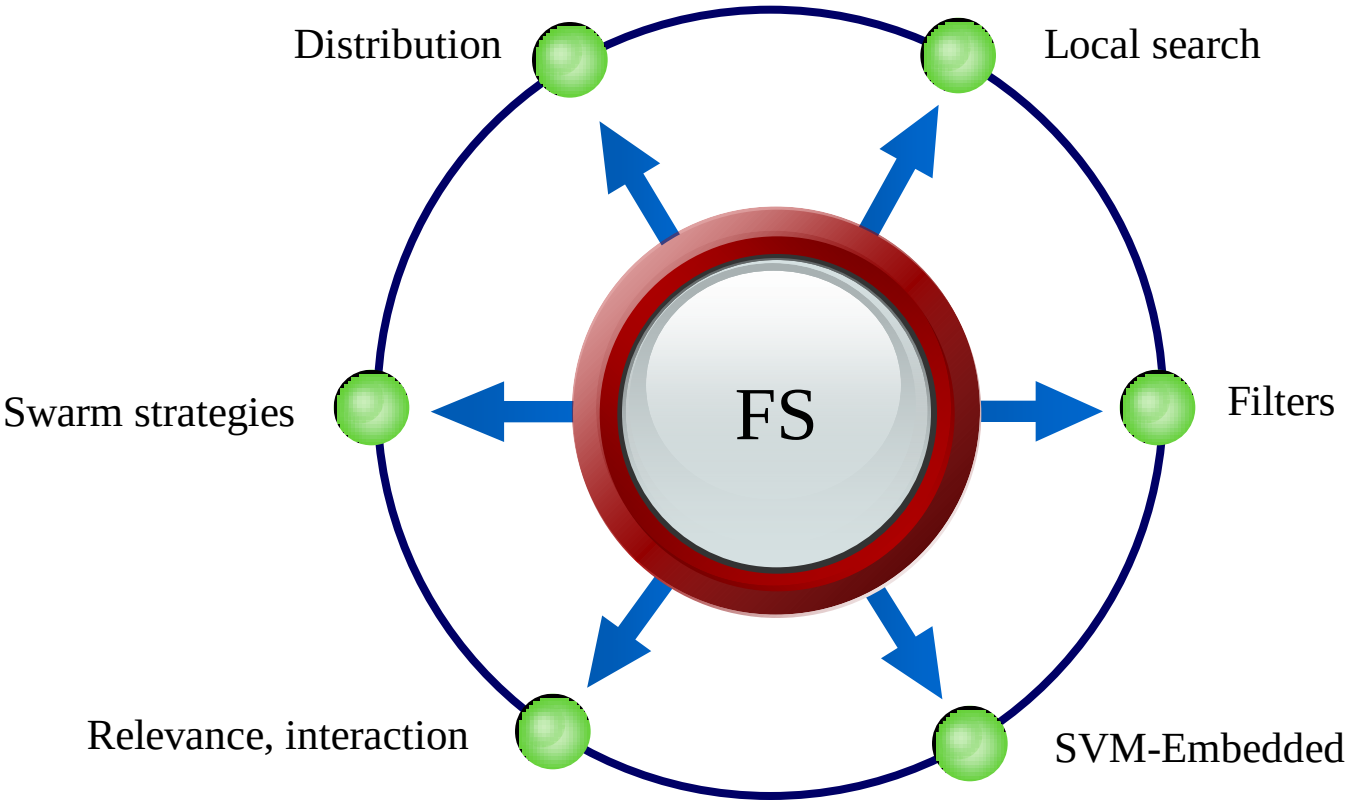


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Diagram

ThemeGallery is a Design Digital Content & Contents mall developed by Guild Design Inc.

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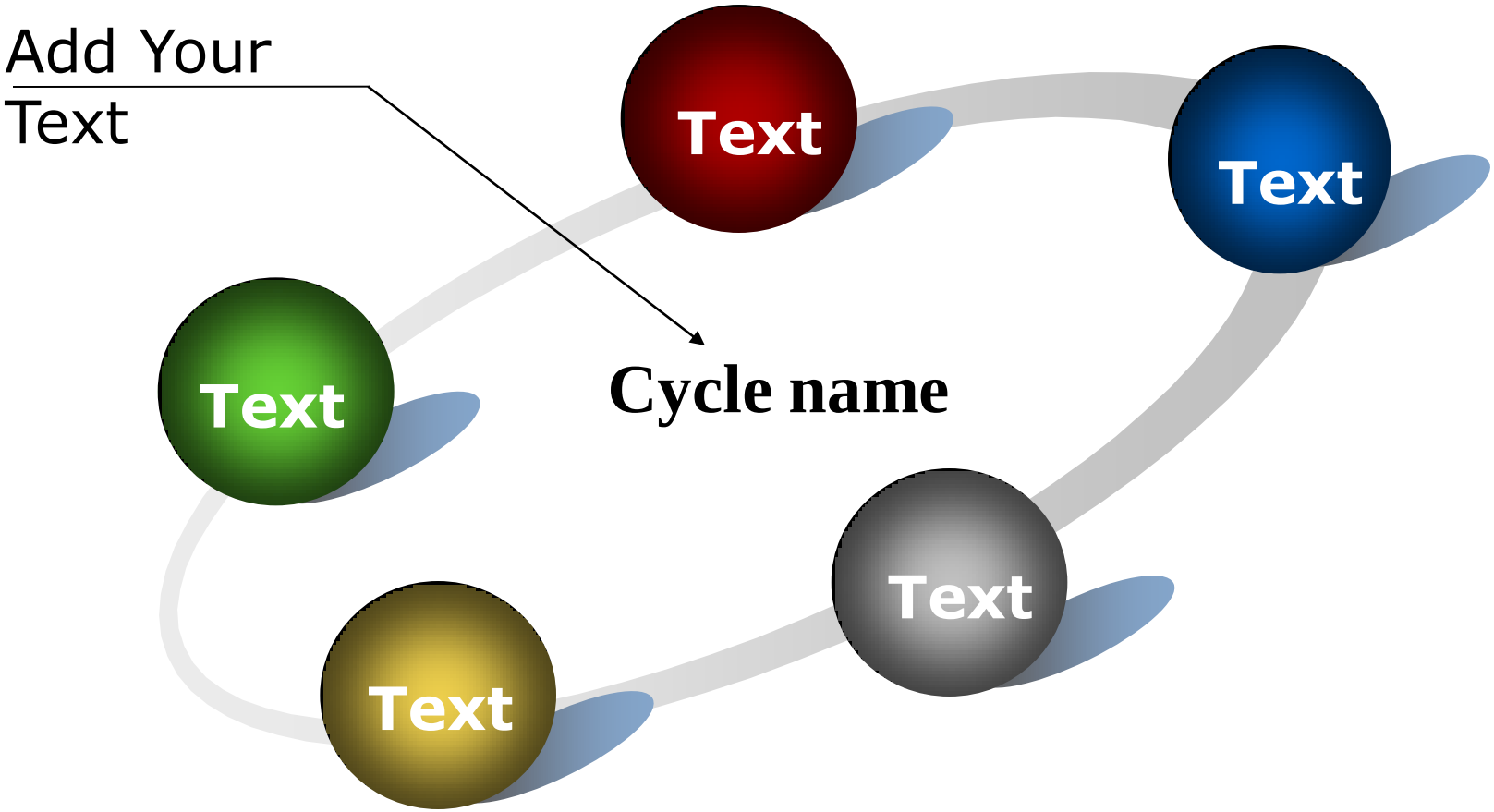
Cycle Diagram



Diagram

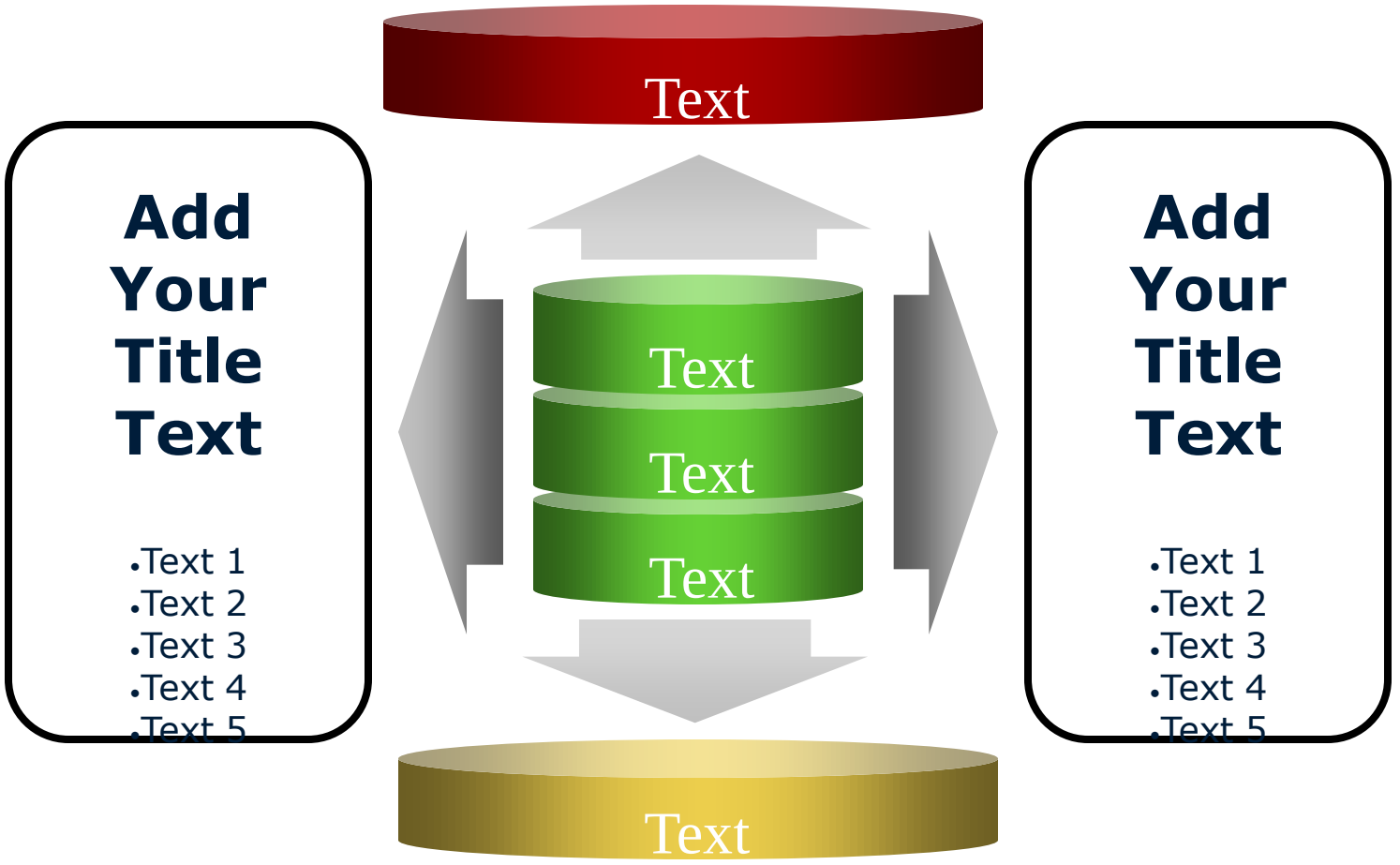

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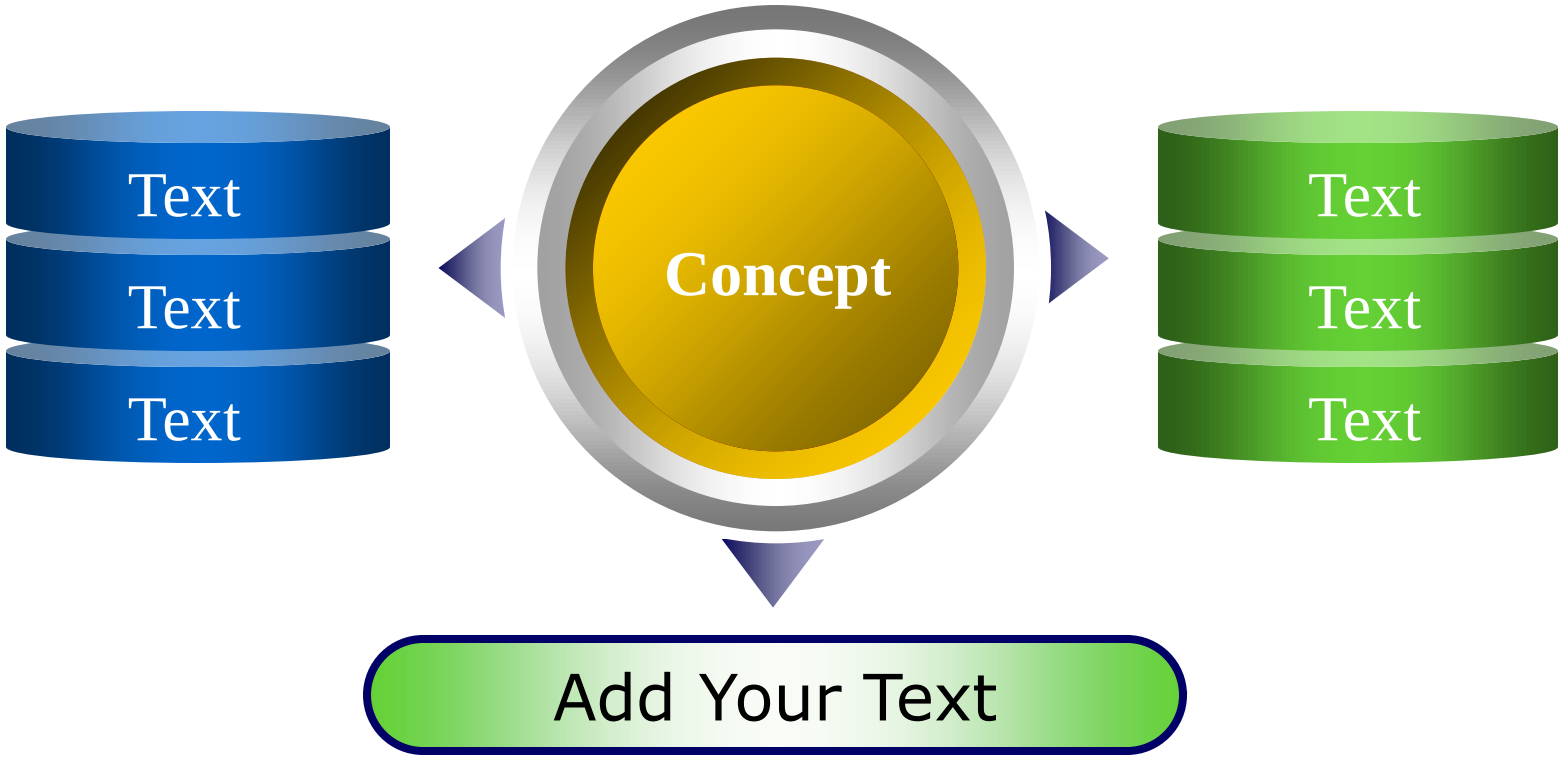
Diagram



Diagram

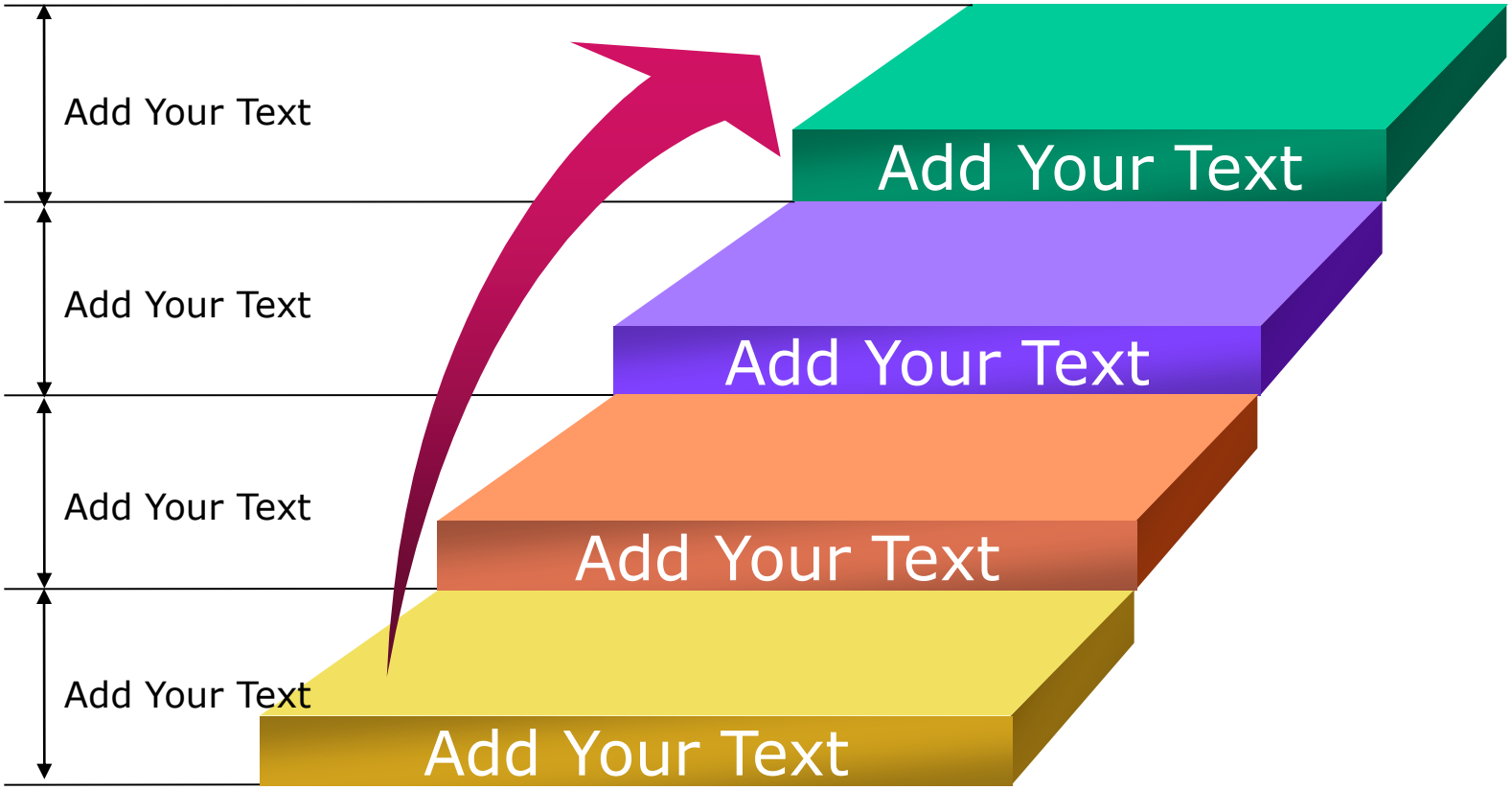

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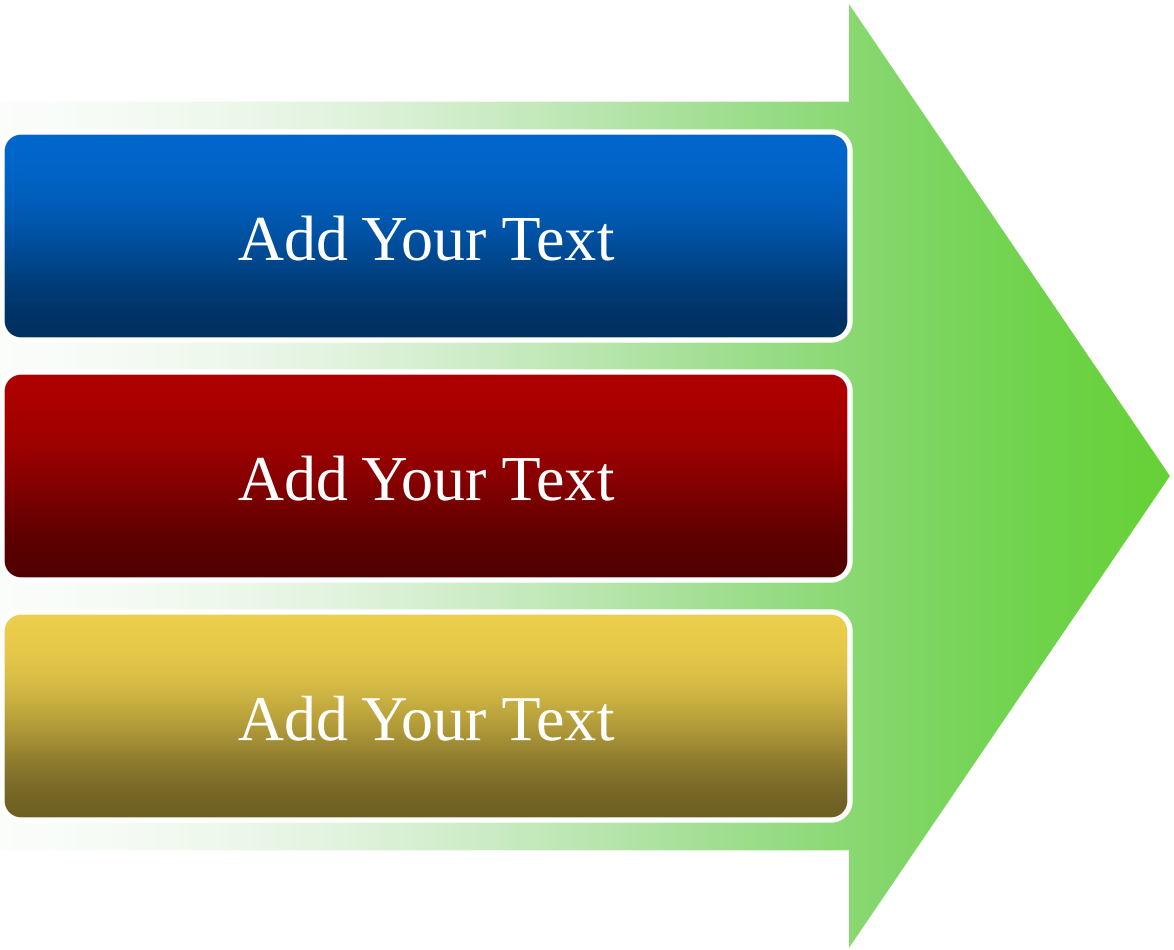
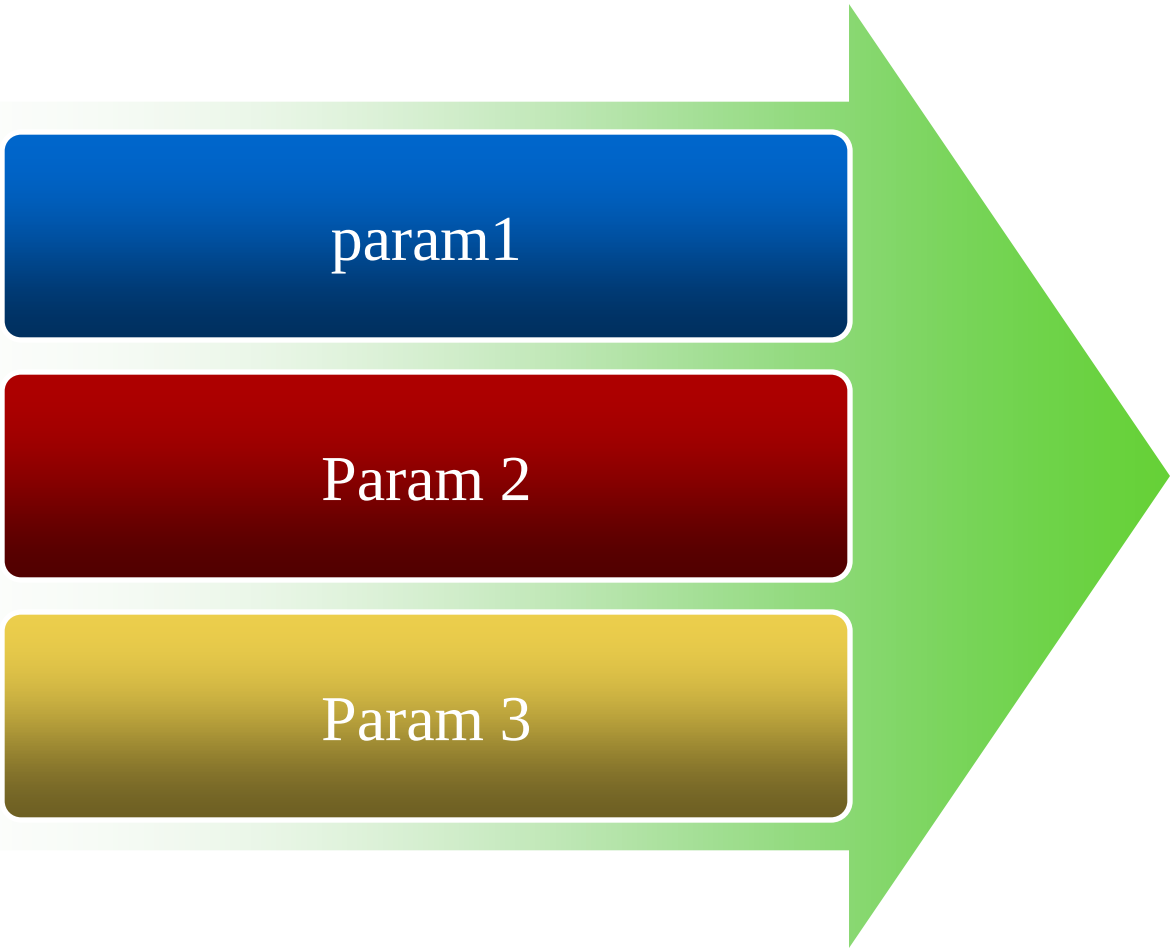
Diagram

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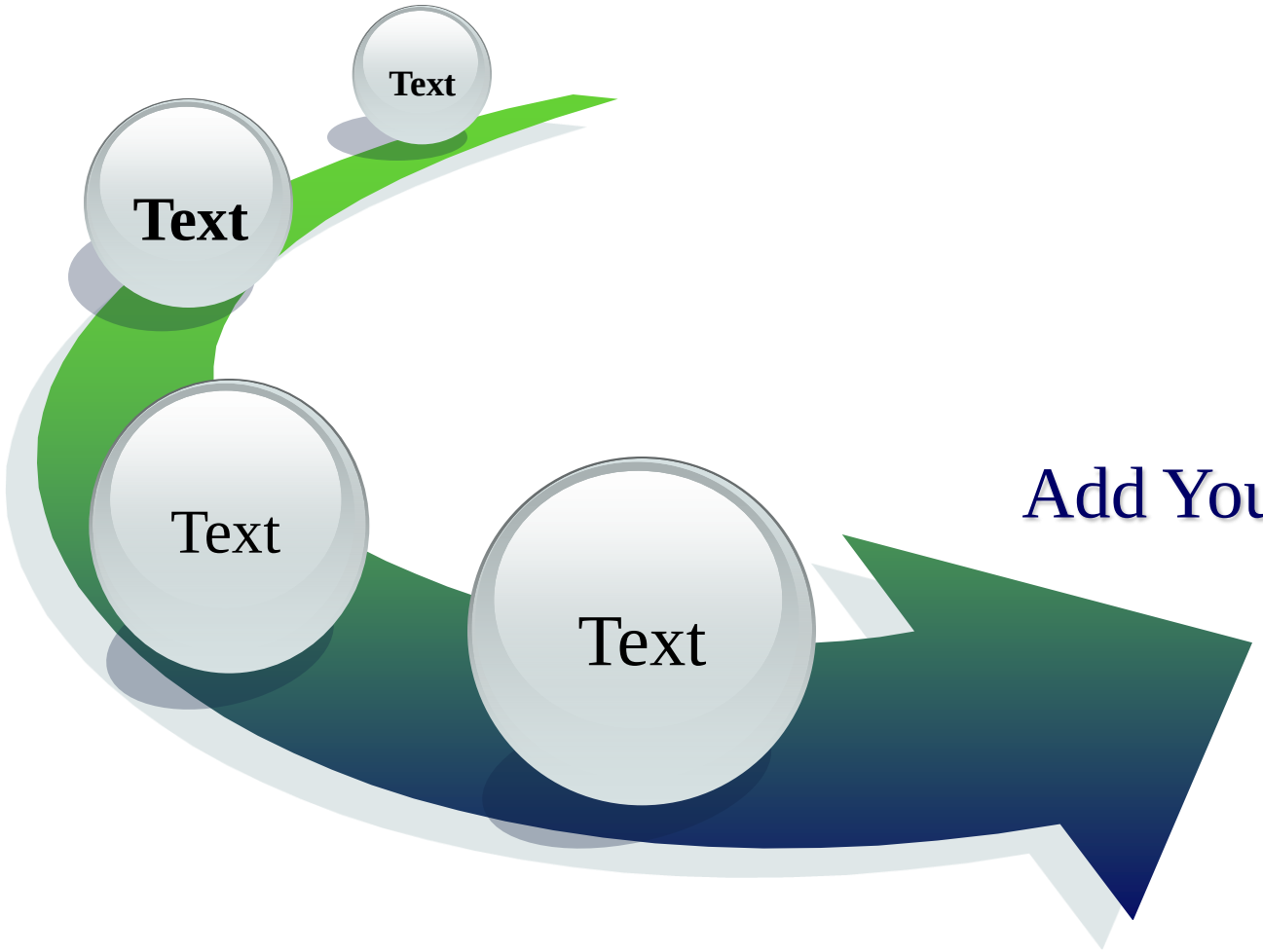
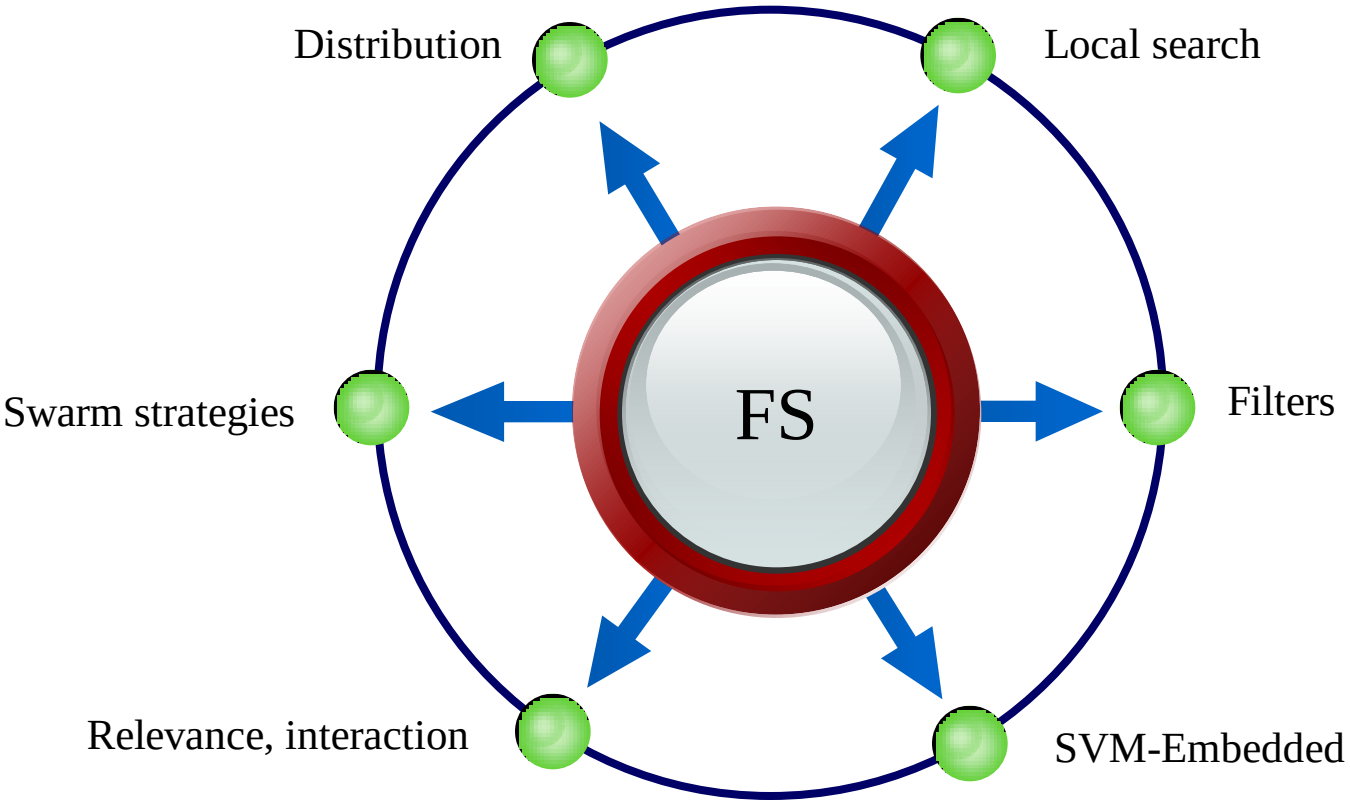
Param 2
Param 3

Diagram

Diagram



Research directions



Diagram

1

ThemeGallery is a Design Digital Content & Contents mall developed by Guild Design Inc.

2

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3

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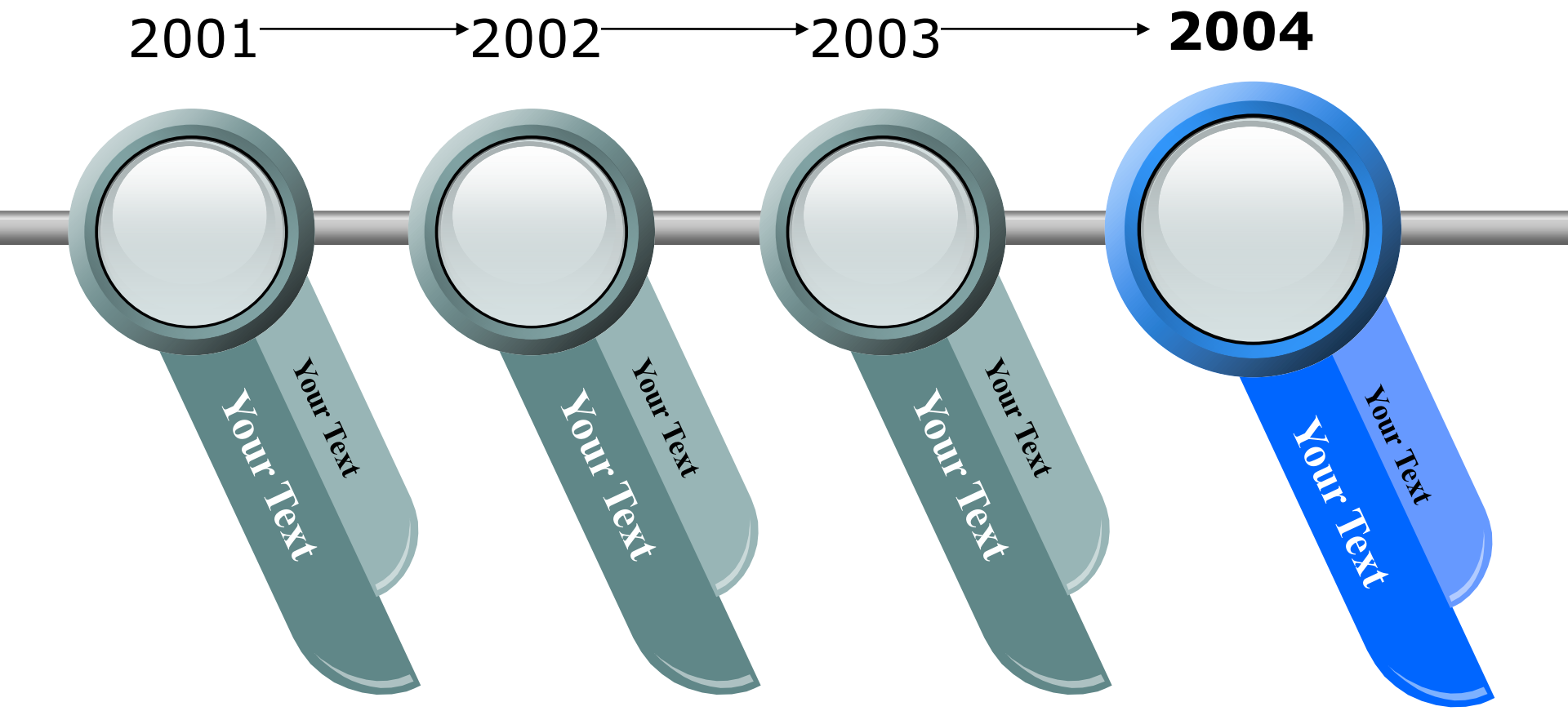
Diagram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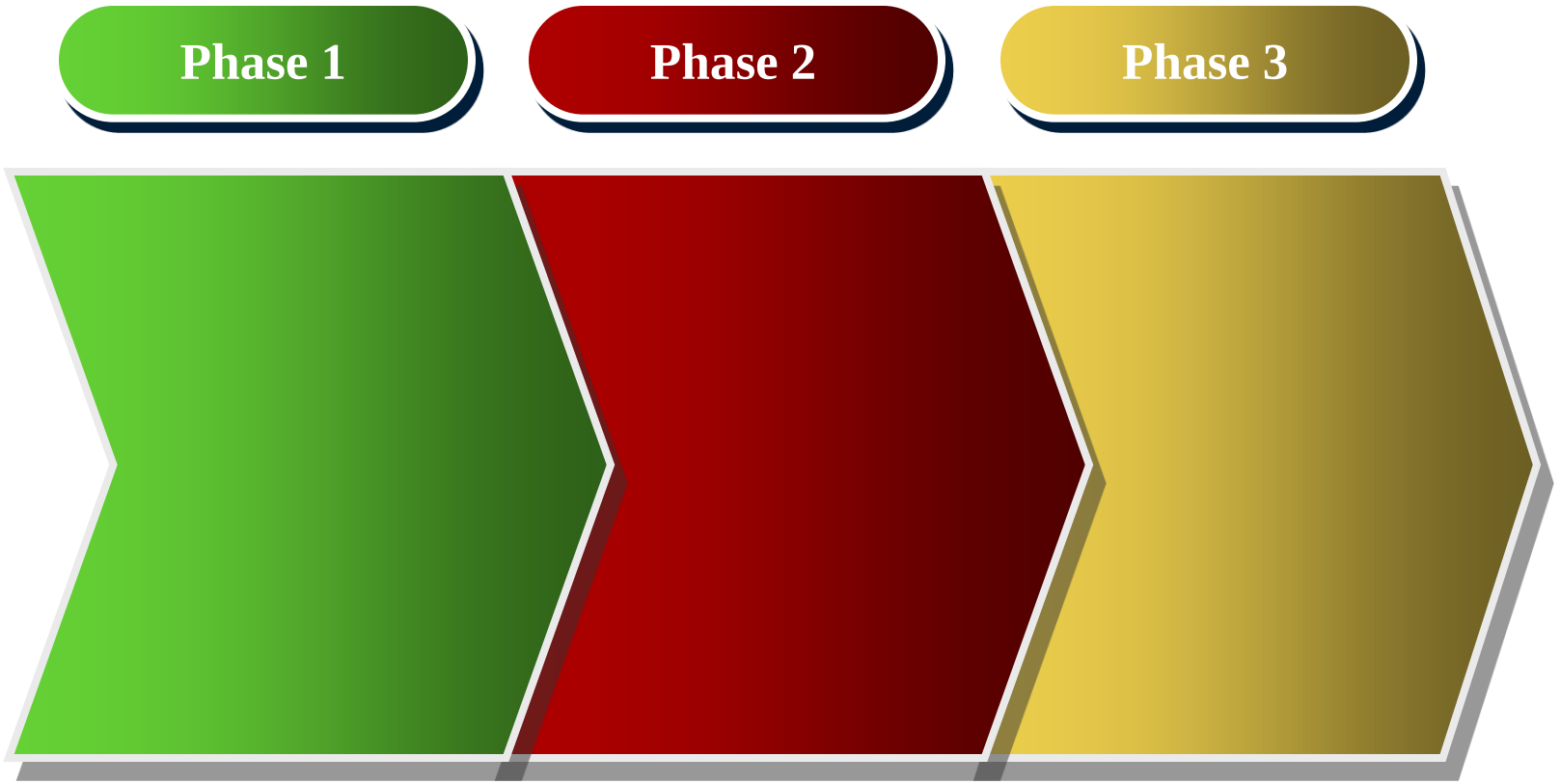
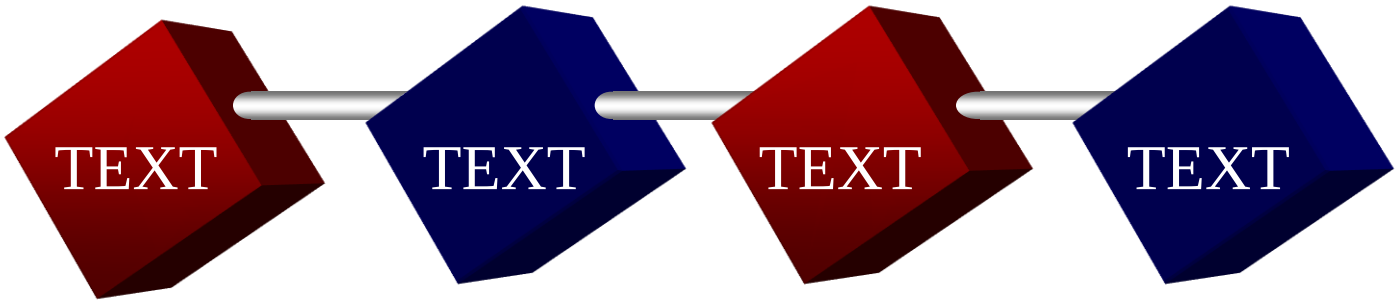
Progress Diagram



Block Diagram



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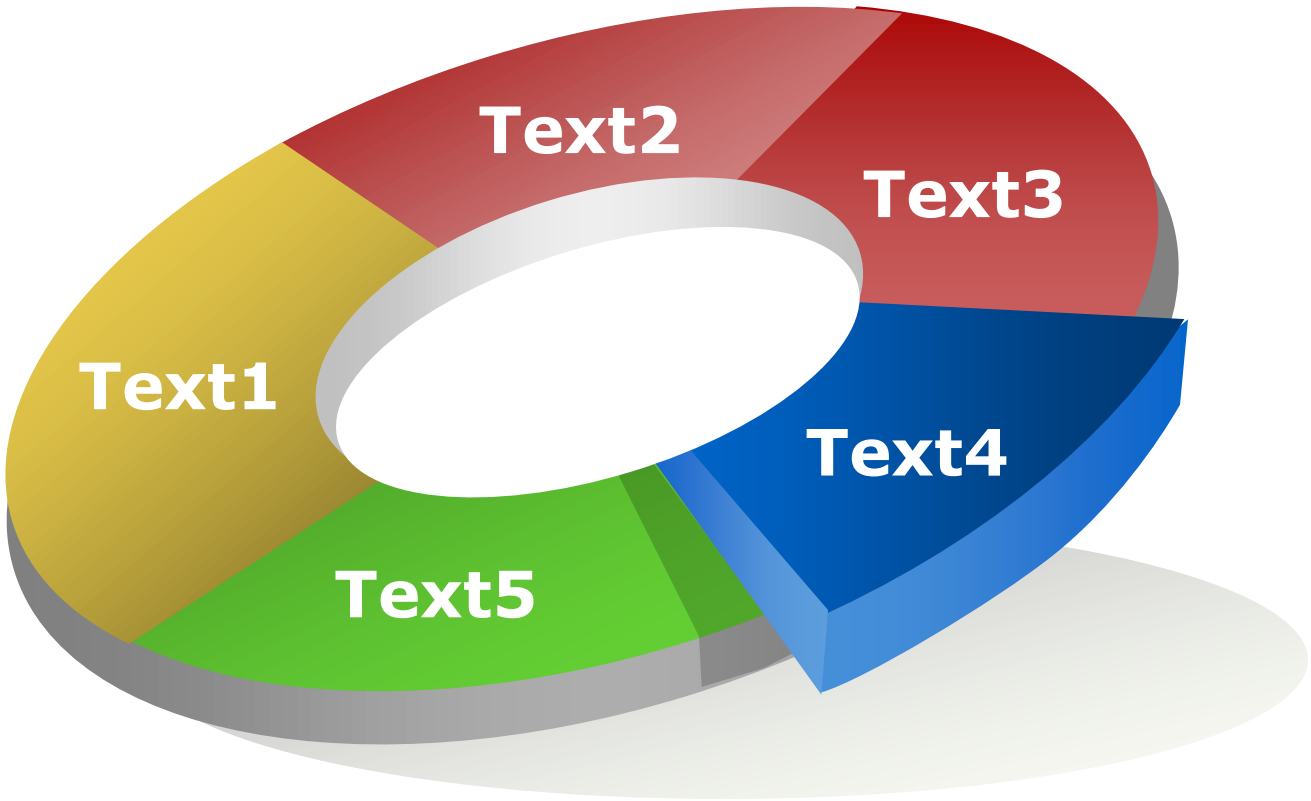
3-D Pie Chart



Marketing Diagram

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