Prepoznavanje nonograma i njihovo rešavanje

Srđan Milaković

Soft Computing 2015

Fakultet tehničkih nauka

Šta je nonogram?

 Nonograms, also known as Japanese crosswords, are picture logic puzzles in which cells in a grid must be colored or left blank according to numbers at the side of the grid to reveal a hidden picture.

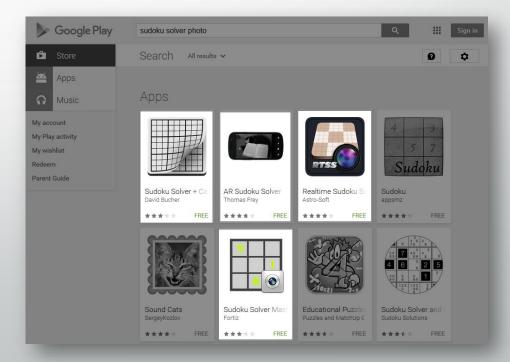
	3	2	1	3	1 3
2 1					
2					
1 3					
2					
2					

			3	2	1	3	1 3
-	2	1					
		2					
1	L	3					
		2					
		2					

Motivacija

- Bubble Cup 7 round 1
- Challenge problem NP complete
- http://www.spoj.com/problems/JCROSS/
- C++ rešenje
- Oko 2000 linija koda

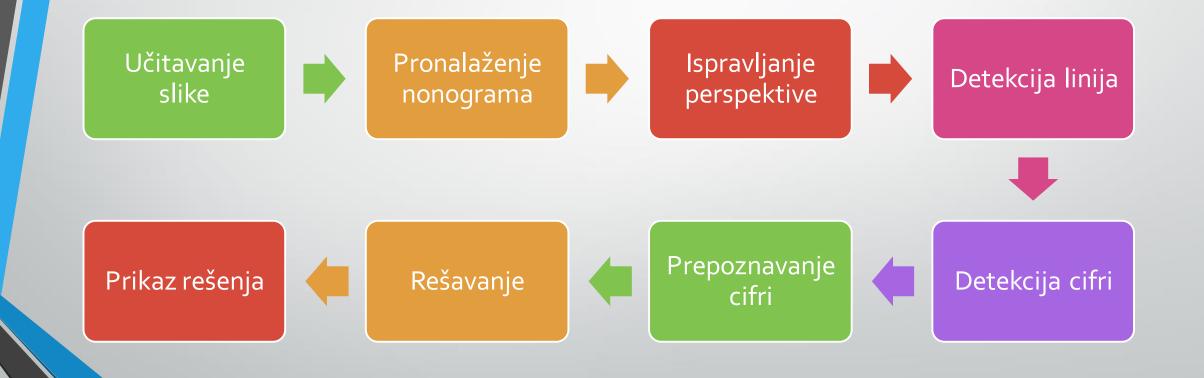
Postoje slične aplikacije za rešavanje soudokua



Slična rešenja

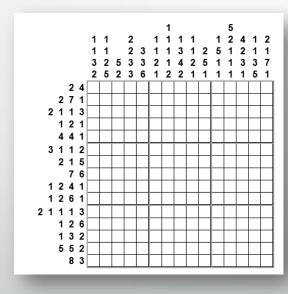
- An efficient algorithm for solving nonograms Chiung-Hsueh Yu, Hui-Lung Lee, Ling-Hwei Chen http://debut.cis.nctu.edu.tw/Publications/pdfs/J54.pdf
- Object detection algorithms analysis and implementation for augmented reality system
 Rasa Zavistanavičiūtė, KAUNAS, 2012
 - Blob detection, Edge detection, Canny edge detector, Double thresholding, Sobel...
- IBM Printed Character Recognition (PCR)
 https://www.research.ibm.com/haifa/projects/image/ocr/pcr.html

Algoritam



Pronalaženje nonograma

- Binarizacija slike
 - Threshold
 - Canny edge detector
 - Image derivate
- Random sample consensus (RANSAC)
- Ramer–Douglas–Peucker algorithm

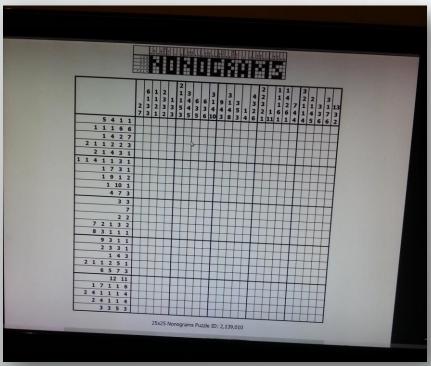


						3
				1	مام	3 1
		3	5	8	3	1
	ω					
2	<u> </u>					
	5					
	5					
	3					
	1					
	1					
	3					
	1 3 2 3					
	3			·		

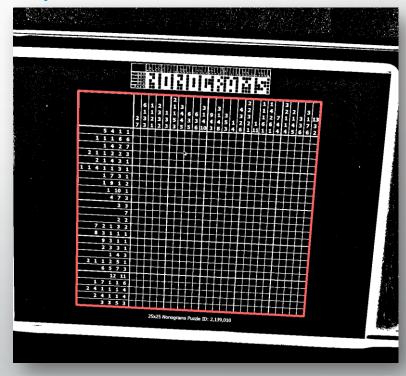
	1 4 1	4	4 1 1	2	1	4	2	9	3	1
1 4										
3										
3 2										
4 3										
8										
3 5										
4										
3 3										
2										
1 1										

Pronalaženje nonograma

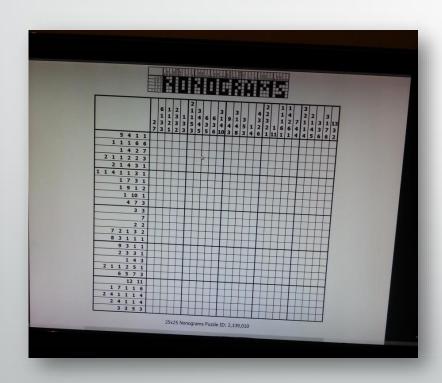
Originalna slika



Adaptive threshold + selection



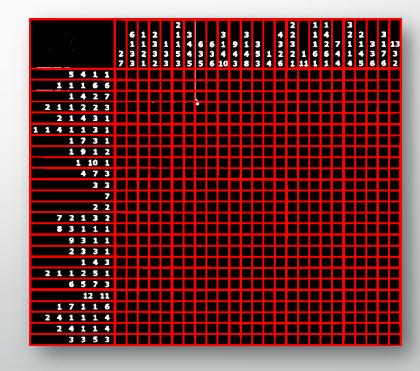
Ispravljanje perspektive



						1	6	1	2	1	2 1 1	3 4	6	6	3	9	3	3		4 3	2 2 3		1 1 1	1 4 2	7	3 2 1	2	3	3	13
						2 7	1 3 3	1 2 1	3 3 2	3 3	1 5 3	4 5	3 5	3 6	1 4 10	4 3	4 8	5 3	1 4	2	2	1	6	2 6 1	4 4	1 4	1 4 5	3	7 6	13 3 2
			5 4	1	1																									
		1	1 1	6	6																									
			1 4		7																									
	2	1	1 2	2	3																									
		2	1 4		1																									
1	1	4	1 1	3	1																									
		_	1 7		1																									
			1 9		2																									
				10																										
			4	7																										
				3																										
					7								0 /																	
				2	2																									
				3	2																									
			3 1	1	1																									
			9 3		1																									
			2 3	3																										
			1																											
	2	1		5																										
			6 5																											
				12	11																									
		1000			6																									
	2		1 1	1	4																									
			4 1	1	4																									
			3 3	5	3																									

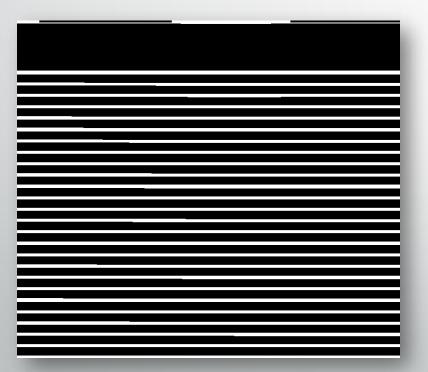
Detekcija linija

- Standardna rešenja
 - Hough Line Transform
 - Probabilistic Hough Line Transform
- Kerneli n x m, n >> m ili m >> n
 - Blur
 - Fixed Threshold



Detekcija linija

Kerneli n x m

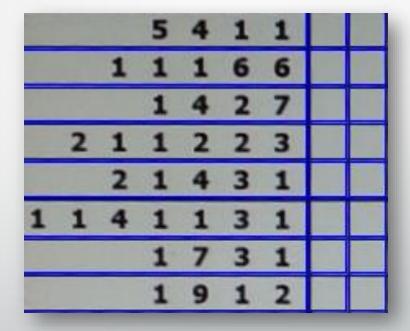


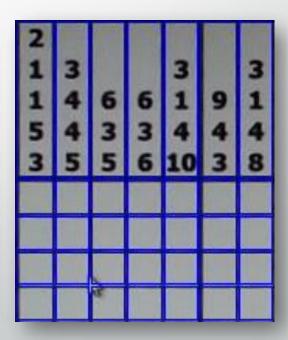
Pravougaonici

	2 7	6 1 3 3	1 1 2 1	2 3 3 2	1 3 3	2 1 1 5 3	3 4 4	6 3	3	3 1 4	4	3 1 4	3 5 3	1		2 2 3 2	1	1 1 1 6 1	1 4 2 6 1	74	3 2 1 1 4	2 1 4	3	Z	13
	7	3	1	2	3	3	5	5	6	10	3	8	3	4	6	1	11	1	1	4	4	5	6	6	2
5 4 1 1																									
11166																									
1 4 2 7																									
2 1 1 2 2 3																									
2 1 4 3 1																									
1 1 4 1 1 3 1																									
1731																									
1912																									
1 10 1																									
4 7 3																									
3 3																									
7																									
2 2																									
7 2 1 3 2																									
8 3 1 1 1																									
9 3 1 1																									
2 3 3 1																									
1 4 3																									
2 1 1 2 5 1																									
6 5 7 3																									
12 11																									
17116																									
2 4 1 1 1 4																									
2 4 1 1 4																									
3 3 5 3																									

Detekcija cifri

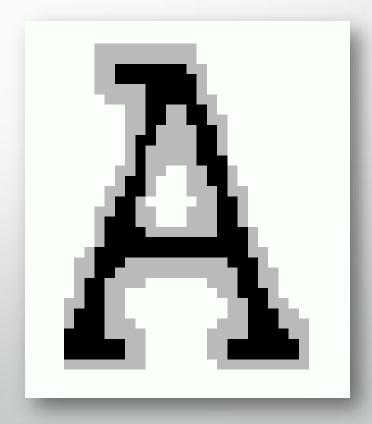
- Dve cifre ili dva broja?
- k-means
- DBSCAN
- Dilate + contours



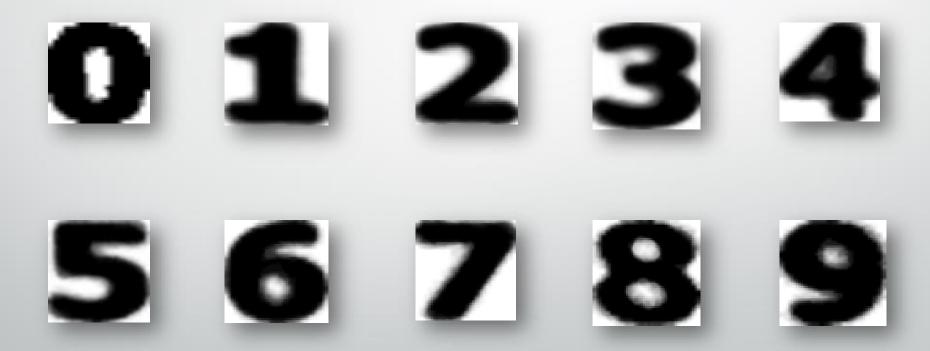


Prepoznavanje cifri

- Printed Character Recognition (PCR)
- Character masks
- Data set
- Mala greška
- Jedan font



Maske

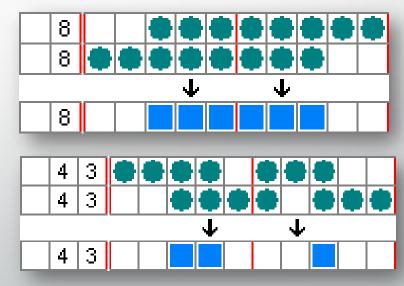


Rešavanje

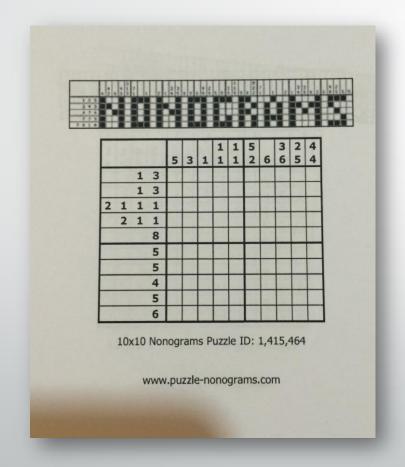
Algoritmi

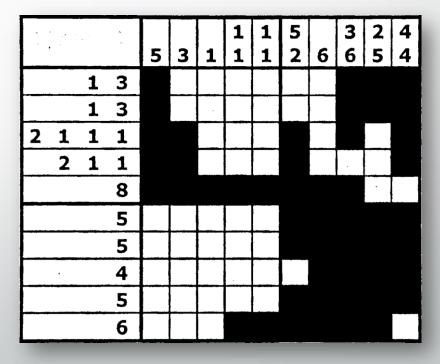
- Genetski algoritmi
- Depth first search
- Logička pravila
 - Cython

Simple boxing



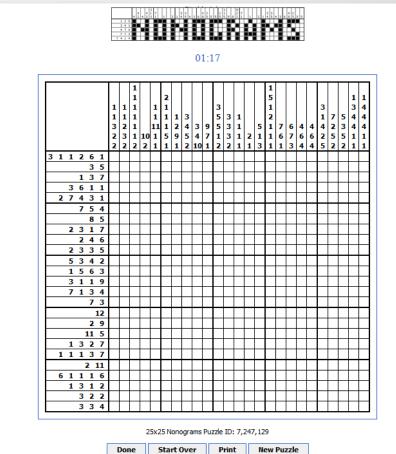
Prikazivanje rešenja





Verifikacija

- http://www.puzzle-nonograms.com/
- Do 20 x 20
- Crno beli nonogrami



Rezultati i performanse

Samsung 18750

Veličina	Rezultat
5×5	5/5 - 100%
10X10	5/5 - 100%
15X15	3/5 - 60%
20X20	1/5 - 20%
25X25	1/5 - 20%

Huawei P7

Veličina	Rezultat
5×5	5/5 - 100%
10X10	5/5 - 100%
15X15	5/5 - 100%
20X20	5/5 - 100%
25X25	2/5 - 40%

IPhone 5S

Veličina	Rezultat
5×5	5/5 - 100%
10X10	5/5 - 100%
15X15	5/5 - 100%
20X20	5/5 - 100%
25X25	3/5 - 60%

Neuspešni testovi

					6	12 6	1	1 3 4 2	3 3	2 2 1 2	3	6	13	6	3	6 5 2 1	1 3		1	1 1 1 4	5 1 1	7	6	2 5 2 4	1 2 1 5	2 5 1		6	_
		,			8 5	12 6	9	2	3 1	2	3 4 2	6 4 3	13 1 5	6 4 7	3 5 3	1	3 4 3	5 1	3	4	4	7 6 5	6 4	4	5	4	12 4	2 4	7 6
	1	1	6	1																									
1	1	5	1	3																									
1	9	1	3	1																									
3	6	2	5	1																									
2 2		2	5	3																									
3	3	1		4																									
		1																											_
2 1	1		3	4																									
		9	3	4																								_	
			13	4		L																							
			7	1	_	_	_					_													_			_	_
	3	6	1	2		L																						_	
4	2	3	2	1																								_	
	_	5	7	3	H	H	H					H	Н															_	
- 6	1			2	H								Н							_									
_		3	6 3	3		\vdash																					-		
-		2	1	3									Н													-	-		_
_	-	-	3	5									Н		Н												-		_
		2	8	4	-								Н		Н								Н						
	2		1	8									Н														_	_	_
	1			11									П												_				_
			2												-											,			-
		1										Т	П		П											-		П	-
	1		1																									-	

·		_			
		5	7	3	
6	1	3	2	2	
		3	6	1.	
			3	3	
		2	1	3	
			3	5	
		2	8	7].	
	2	6	1	8	
	4 .	4 (~	4 4	

Neuspešni testivi

						4 4 5	4 5 5	4 7 4	2 1 5 6	2 10 6	1 10 5	2 4 2 1 5	3 2 1 4	4 1 6	4 3 6	3 1 6	7 2 9	7 1 6 3	6 1 6	2 2 6	2 4 3 5	1 4 3 4	2 6 1 1	3 6 3	4 2 2 2	4 1 5 1	4 2 6	3	4 3	2
	1	10)	3	3																			;						
4		_ 1		1	3								1																	
	4		′_	3	1																									
3	2	. 3	3	1	67																									
		1 3	2	6	3																									
1	2	: :	L	7	7																									
	4	1 1	L	3 1 3 1 6 7 2 3 3 3 1 1 1 1 4 5 3 4 7	3 3 4 3 2 4 1 2 1 3 1 3 1 1 5 1 1 1 1 1 1 1 1 1 1 1 1 1																									
		7	7	3	1																							_		
		3	3	2	7																									
				3	1,																									
				3	3																									
	4		4	1.	2																									
5	1	. :		1.	1.																									
	4	3	;	1.	1.																									
		. :	,	1.	7																									
			;	2 -	6																									
			;	5	4 s																									
	3	_;	:	3	3	-																								
_	_	_ :	:	4	Z.	1	-																							
<u> </u>					1	1																								
_	_	i	:	4	ŧ	┡		L					L						Ц					_						
_		1	1	4	2	1																								
_			1	3	7	-							_																	
_	_		1		5				_		Ш		_														_			
			_	4	8				L																			7		

					4 5	5	7 4	5	10 6	10 5	1 5
	1 10) :	3	3	:						
4	8	:	. 3								
	4		3								
3	2	7 : 3 : 2 (. 3 3 4 6 3	7				_			
		2 (53	}							
1	2	1 :	, :	7							
	4	1									
		7	3	7							
		3	2 .								
			} ;	11							
			3 :	h							
		4 :									
5			. :								
		3 :									
		6 :		7							
				;							
	·	} .	; 7								

Neuspešni testovi

		3		1	1							2		\$ 10 m
	11	4 1 1 2	4	6	3	1	9	3	7 2	2	3	3	7	7
1 2 2 3													1	
2 2 3 5 3 2										n.a.elen		-		
3 3 2				- 44-						-	_		_	7
3 11 1 8									: 4	e manual i				
1 5 4					7					-				.,
1 4										- 40		***************************************		- 1 - 1
3 1 2 1									,				V.	4
1 1 3 2		-	-					7				- « .		1
2 1 3							-		1	-				r
3 2		3 3 32 3					·		1 4		 			1.5

1 2 2 3 1 9 7 3 7 7 1 4 9 3 2 2 3 1 8 6										
1			1		1					
1	1	. 1	ı i	İ	. !		·			
1		,]	1	Ì				
3 1 9 7 3 7 7 1 4 9 3 2 2 3 1 8 6			i i	!			w 1			1 × 5
3 1 9 7 3 7 7 1 4 9 3 2 2 3 1 8 6	4 1	1		1						*/
3 1 9 7 3 7 7 1 4 9 3 2 2 3 1 8 6		j		İ	!			7		
3 1 9 7 3 7 7 1 4 9 3 2 2 3 1 8 6	-	1								
1 4 9 3 2 2 3 1 8 6				-	-					
1 4 9 3 2 2 3 1 8 6		76			7			7	-	46
1 4 9 3 2 2 3 1 8 6	4	4 1			7			4	- -	4
	i i				-			-	7	"
		.	A				-		-	
	7 '	4	W	4		7	7	4		A
	400	40	9			27 4	₩	4	7	1
									- 7 .	77
							, , ,			
						1.5	٠ ,			ı.
						·	•			
		·								4
							,		-	-
							,			ŧ'
								-	-	
, , , , , , , , , , , , , , , , , , ,										1
									* -	,
The state of the s										
			,				F		_	-
						,				
						1	1			'
				•				·		-
			i i		1.	•	`			1 6

Neuspešni testovi

			-																		•	1		
		1	1	3	2						6	1			1	5			2	1	5			
	6	1	1 3 4 2	3 3 1	2 1 2	3	6	13 1 5	6	3 5 3	5	3		1 3 3	1 1 4	1	7	5	5	2	1		6	
	8 1	2 9 5 1	4	3	1	3 4 2	4	5	4 7	3	5 2 1	4	5	3	4	1 4	5	4	2	1 5	14	12 4	4	7
1 1 6 1	•	÷	-	-	-	-	-	-	Ė	-	-	-	-	-	-	-	_	-	-	-				
1 1 5 1 3	-		-	_							1							-						
19131				-																				
3 6 2 5 1		-												_										
2 2 4 2 5 3			-	-																				
3 3 1 4 4			_									-									_	_		_
1 1 10			-		-																		_	_
2 1 1 1 3 4					-																	_		_
9 3 4																							_	_
13 4																								_
5 7 1																								
3 6 1 2																								-
4 2 3 2 1																								-
5 7 3										-						:								_
6 1 3 2 2		_	L							-										-		:	-	
3 6 1		_	L			-															-	1 1	_	ļ
3 3		+				1			-												!	!	1 1	
2 1 3		1 1								1	- 1							1		1	!		Ŀ	·
3 5		_		-								_	_						_		!			-
2 8 4	\vdash	-							1	-				1				1			1 1	1	⊢	
2618		+	-		-										1	-	:		1	1	i	-	-	-
1 1 2 11		+	1			-		- 1			- 11		:					1		-		_	-	
1 2 11	1		-					- 1				_	1		1	1	-						_	-
1 7 1			1	1		-	1	-		_			!		1			'						-
1 3 1 1					<u> </u>	Ŀ						1	10	1	!			,						<u></u>

3 4	6 4 3	13 1 5	4.7	3 5 5	- 1
		!			
				į	

Hvala na pažnji

Srđan Milaković

srdjan.milakovic@outlook.com