Handwritten Chess Scoresheet Recognition Using a Convolutional BiLSTM Network

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Overview



Overview

- Objective: Create superior recognition framework
 - Utilizing document info & image data
- Two post-processing methods
 - Fully autonomous
 - Semi-autonomous
- Trained on the Handwritten Chess Scoresheet (HCS) Dataset



Motivation

- Chess is the most popular board game
 - 605 million active players
- Tournament managers spend hours entering data manually
- Camera-based applications are convenient
- A specialized framework increases accuracy over a traditional Latin handwriting recognition network





A Brief Explanation of Standard Algebraic Notation (SAN)

Format

- 2 sheets per game
 - One sheet from each perspective
- Official record for chess match
 - Settle disputes
 - Verify winners
- Written on paper

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-	WHILE	BLACK		TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT	States of the State of the Stat
1	dy	NFG	31	P& OBKh1	h6
2	CY	26	32	1	
3	NC3	d5	33	<u></u>	
4	Nf3	Bb4	3.4	156	ICK
5	B d 2	0-0	35	Rea	signs
6	23	NCG	36	-	
7	B\$3	BdZ	37		
8	0-0	BQ7	38		
9	0,3	dxc4	39		
10	Bx C4	Bdb	40		
11	Nb5	N 94	41		
12	h3	NFG	42	-	
13	RCI	a 6	43		1
14	NX d.G	cxd6	44		
15	Re1	65	45		
16	6 d 3	d5	46		1
17	N 25	Rfc8	47		
18	NXCG	BXCG	48	da .	
19	f3	Rat	49		
20	24	Roct	50		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
21	25	NOF	51		
22	064	02.08	52		
23	BdB	R 67	53		
24	ad2	N66	54		
25	63	Rat	55		
26	Bes	Ad8	56	4	4
27	RC3	0.5	57	man and a state of the state of	
28	Rec1	RCal	58		
29	Bxb6	Qx 56	59		
30	RXCGC Kddy	Qxd4=	60		PLACK MARK
CID	CLE CORRECT REC	WHITE WO	N	DRAW	BLACK WON

Chess Notation

Piece	Disambiguating	If	Destination	Destination	If	If Check
	File/Rank	Capture	File	Rank	Promotion	or Mate
$Pawn \sim (none)$ $King \sim K$ $Queen \sim Q$ $Rook \sim R$ $Bishop \sim B$ $Knight \sim N$	Either from a - h or from 1 - 8 for disambiguating File or Rank respectively	Х	One choice from a - h	One choice from 1 - 8	= followed by the Piece Q, R, B or N	Check ~ + Mate ~ #



Chess Notation

Sample	Move	Diago	Dis.	Dis.	Cantuna	Dest. Promoto		Check
Move	Description	F lece	\mathbf{File}	\mathbf{Rank}	Capture	\mathbf{Square}	romote	Mate
Nf3	Knight to f3	Ν	2	2	~	f3	~	\sim
R1f4	Rank 1 Rook fo $\mathbf{f4}$	R	2	1	2	f4	2	\sim
Bxe5	Bishop takes e5	В	2	2	х	e5	2	\sim
Rdf8	d-file Rook to f8	R	d	2	~	f8	~	\sim
Qh4e1	h4 Queen to e1	Q	h	4	~	e1	~	\sim
e8=Q	Pawn to e8 promotes to Queen	2	2	2	2	e8	=Q	~
e4	Pawn to e4	2	2	2	2	e4	2	~
Qxf7#	Queen takes f7 Checkmate	Q	2	2	х	f7	2	#
Bxc3+	Bishop takes c3 Check	В	2	2	х	c3	2	+
dxe5	d-file Pawn takes e5	2	d	2	х	e5	~	~
0-0	Short Castle	~	~	~	\sim	~	~	\sim
0-0-0	Long Castle	\sim	\sim	\sim	\sim	\sim	\sim	\sim





The Handwriting Chess Scoresheet Dataset

Image Capture

- Captured with phone camera
- Natural lighting

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- Gathered from live tournaments
- Standard corner detection transformation

1	WILLE	DLACK	TYTELE .	
1	dy	NFG	31 PACEK	h1 h6
2	CÝ	26	32	
3	NC3	d5	33	1
4	Nf3	Bb4	3.4 15	LACK
5	Bd2	0-0	35 R	esigns
6	23	NICG	36	
7	B\$3	BdZ	37	
8	0-0	BQ7	38 *	
9	0.3	dxc4	39	
10	Bx C4	Bdb	40	· · · ·
11	Nb5	N94	41	
12	h3	NFG	42	
13	RCI	a 6	43	1
14	NXdG	cxd6	44	
15	Re4	65	45	
16	Bd3	15	46	
17	Ne5	Rfc8	47	
18	NXCG	BXCG	48	
19	£3	Rat	49	
20	24	Ract	50	
21	25	N&F -	51	
22	064	02.08	52	
23	Bab	R 67	53	
24	Bd2	N66	54	
25	63	Rat	55	
26	Best	Ad8	56	2
27	RC3	0.5	57	
28	Rect	RCa8	58	
29	Bxb6	Qx 56	59	
30	RACGERANS	Qxd4+	60	A DIAGU
	CLE CODDECT DEC	WHITEV	VON DRAW	BLACK WON

Dataset Contents

- 158 games
- 215 individual pages
- 13,810 tagged handwriting samples
- Ground truths in single .txt file

http://tc11.cvc.uab.es/datasets/HCS_1/



https://sites.google.com/view/chess-scoresheet-dataset/home/



Sample Scoresheet Images

White's Perspective

1	dy	NF6
2	CY	26
3	NC3	d5
4	Nf3	Bb4
5	B \$2-	0.0
6	23	NCG
7	B\$3	BdZ
8	0-0	QQ7
9	9,3	dxc4
10	Bxc4	Bdb

Black's Perspective





Ground Truth Tagging

- Each text box has an associated ground truth
- Testing set contains ground truth for the game, not individual sheets



Training Set Ground Truths

001 1 white.png d4 001 1 black.png Nf6 001 2 white.png c4 001 2 black.png e6 001 3 white.png Nc3 001 3 black.png d5 001 4 white.png Nf3 001 4 black.png Bb4 001 5 white.png Bd2 001 5 black.png 0-0 001 6 white.png e3 001 6 black.png Nc6 001 7 white.png Bd3 001 7 black.png Bd7 001 8 white.png 0-0 001 8 black.png Qe7 001 9 white.png a3 001 9 black.png dxc4 001 10 white.png Bxc4 001 10 black.png Bd6

Testing Set Ground Truths

001 0 1 white.png d4 001 0 1 black.png Nf6 001 0 2 white.png c4 001 0 2 black.png e6 001 0 3 white.png Nc3 001 0 3 black.png d5 001 0 4 white.png Nf3 001 0 4 black.png Bb4 001 0 5 white.png Bd2 001 0 5 black.png 0-0 001 0 6 white.png e3 001 0 6 black.png Nc6 001 0 7 white.png Bd3 001 0 7 black.png Bd7 001 0 8 white.png 0-0 001 0 8 black.png Qe7 001 0 9 white.png a3 001 0 9 black.png dxc4 001 0 10 white.png Bxc4 001 0 10 black.png Bd6

Offline Chess Scoresheet Recognition Framework



Pre-Processing

- Otsu's method of thresholding
- Long horizontal/vertical kernels
- Quadrilaterals selected by size

and position









Post-Processing



Post-Processing



Fully Autonomous Method

- Does not require user input
- Ideal for making predictions quickly

Semi-Autonomous Method

- Requires user input
- Lower error rate
- For scenarios that require high precision

Fully Autonomous





Semi-Autonomous

- Follows autonomous logic
- Confidence threshold = 90%
- Interrupts user in following cases:
 - Strong conflict
 - Weak conflict
 - Weak match
- Interruption rate = 7%

1 64	29	31	1	61	.e.,	31	
2 NF3	NCG	32	2	142.0	NCG	32	
3 74	9829	23	3	de	2804	33	
4 Nx24	NK6	34	4	arda	NF6	34	
5 NYL6	Bxcb	35	5	NXC	DACE	35	
6 er -	N 25	36	6	23	Not 5	36	
1 C VI	N 66	37 /	7	109	1066	37	
S NC3	Bes	38	8	NC 2	PCS	38	
a 893	34	205	9	005	ab ,	39	-
10 0-0	Beb	40	10	0.9	pe b	40	
11 e+46	C×26	41	11	exup.	CXOG	41	
12 63	0.46	42	12	P3	C. TO	42	
13 8 62	B24 :	43	13	012	12dh	43	
14 (2)2	0-0	44	14	6.82	0-0	44	
15 Bxh7+	KXWY	45	15	lex high	KAN7	45	
16 Neil	Bx + 3+	46	16	N AN	DAT C	46	
17 Fx+2	G.h6	47	17	EXEL	ext o	47 -	
18 NA 54	K 68	48	18	14934	K95	48	-
19 NKPE	Qidz	49	19	MX Clo	Q×01	49	
20 Rx01	7 206	50	20	1-100	1260	80	
21	0	51	21	KYUP		51	
22	0,	82	22			52	
23		53	23			53	war.
24		54	24		-	54	/
25		55	25			55	
26	1		26		-	L	1.2
27	k	-xh7	27			r.	ANT
28			28	-			22
29		Pradiction W. Vyh7: 0 450	29	1	D	adiction D.	Kh7 0 794
30	1	Teurenon W: KXII7: 0.459	30		- PI	rediction B:	KII/: 0.764

Weak conflict, verify move: Kxh7

xh7

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Training and Results

Training

- Pretrained on IAM dataset
 - 86,000 word samples
 - 80 valid characters
 - Max word length = 27 chars
- Finetuning

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- 4,706 samples from 35 unique pages
- 47,060 with 10:1 data augmentation
- Epochs = 10
- Batch size = 32
- LR = 0.0005

probabili	hics	Deven	, gr	ery m	nath	nema	fics
distributed	ma	Hiple	per	iod	ic P	sque	ne
in heritance	In	hintan	ui	nhorit	ance	anhere	tence

Recognition Accuracy

Post-processing	CRA	MRA	Interruption Rate
None	92.1%	82.5%	None
Autonomous	95.5%	90.1%	None
Semi-autonomous	98.1%	97.2%	7.00%

Human Error Rate $\approx 2\%$





Conclusion

Future Scopes

✓ Incorporate game validation into post-processing
 ✓ Increase prediction accuracy with most played moves
 ✓ Expand HCS dataset
 ✓ Balance rare data (long castles)
 ✓ Create user friendly mobile application





Thank You