



中国科学院空天信息创新研究院

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# CNN-based Golf Swing Classification Revisited

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Data Acquisition

Data Preprocessing

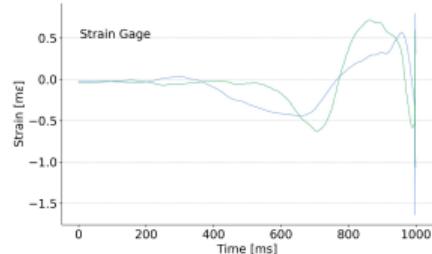
CNN Architecture

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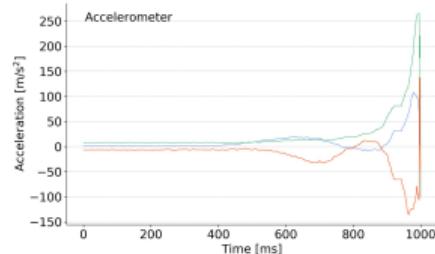
# Data Acquisition

## Golf swing

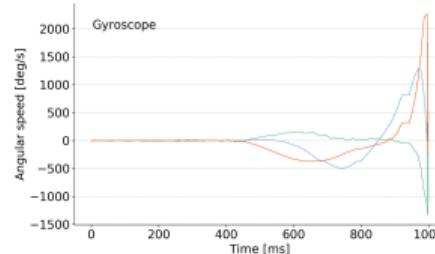
- ▶ Shape:  $10 \times 1000$ , fixed dimensionality
- ▶ Sensors (Indices): SG (0#, 1#), Accelerometer (2#, 3#, 4#), Gyroscope (5#, 6#, 7#)
- ▶ Length: 1000 points / swing, fraction used from 350 to 995



(a) SG



(b) Acc.



(c) Gyro.

图: Example of one golf swing

# Data Acquisition

## Label

- ▶ Shape × Golfer#

表: Golf swing labels

ID	#Golfer	Shape	Count	ID	#Golfer	Shape	Count
0	2	Straight	30	10	1	Hook	5
1	1	Straight	79	11	4	Straight	11
2	4	Fade	2	12	3	Straight	15
3	1	Pull	9	13	4	Slice	2
4	4	Push-Slice	1	14	1	Fade	7
5	2	Pull	1	15	1	Push-Slice	1
6	1	Pull-Hook	3	16	4	Push	10
7	1	Slice	9	17	1	Draw	11
8	1	Push	9	18	2	Push	4
9	4	Draw	4	Total count		213	

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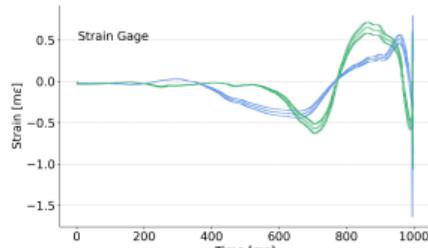
Evaluation

# Data Preprocessing

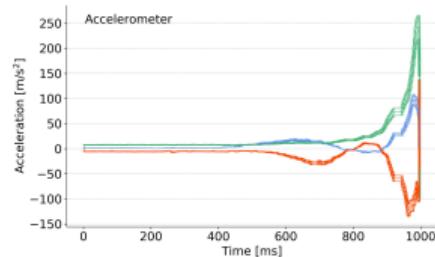
## Data Augmentation

- ▶ Time translation
- ▶ Amplitude rescaling

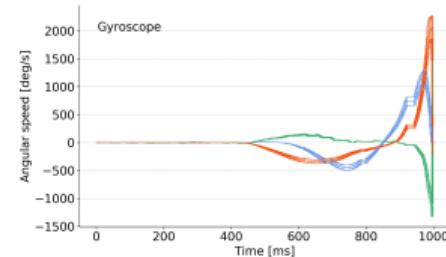
$$y^{(i)} = \gamma x^{(i)} (t \pm \Delta t) \quad (1)$$



(a) SG



(b) Acc.



(c) Gyro.

图: Data augmentation of one golf swing

# Data Preprocessing

## Label

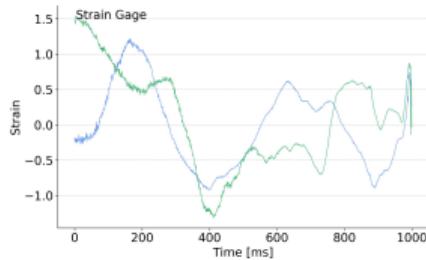
表: Augmented golf swing labels

ID	#Golfer	Shape	Count	AugCount	ID	#Golfer	Shape	Count	AugCount
0	2	Straight	30	60	10	1	Hook	5	45
1	1	Straight	79	79	11	4	Straight	11	55
2	4	Fade	2	38	12	3	Straight	15	60
3	1	Pull	9	54	13	4	Slice	2	38
4	4	Push-Slice	1	32	14	1	Fade	7	49
5	2	Pull	1	32	15	1	Push-Slice	1	32
6	1	Pull-Hook	3	42	16	4	Push	10	50
7	1	Slice	9	54	17	1	Draw	11	55
8	1	Push	9	54	18	2	Push	4	44
9	4	Draw	4	44	Total count				213 917

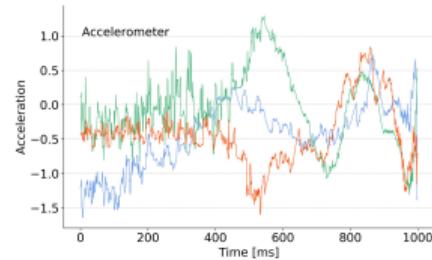
# Data Preprocessing

## Data Standardization

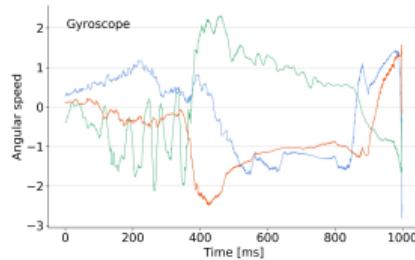
$$y^{(i)'} = \frac{y^{(i)} - \mu(y^{(i)})}{\sigma(y^{(i)})} \quad (2)$$



(a) SG



(b) Acc.



(c) Gyro.

图: Data standardization of one golf swing

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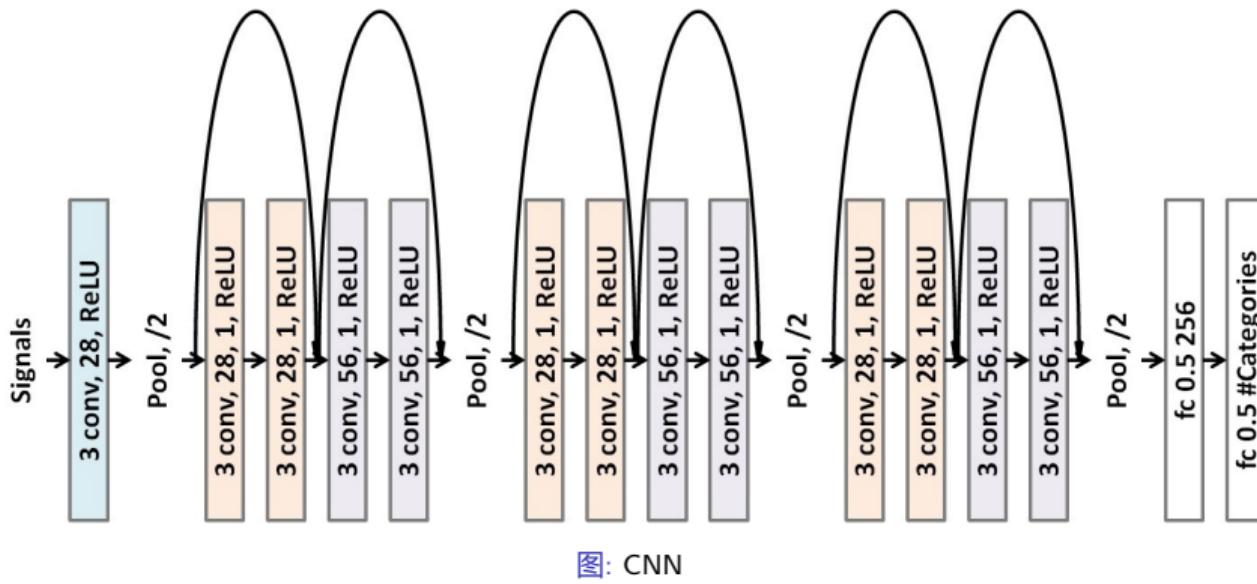
CNN Architecture

Evaluation

# CNN Architecture

## CNN

- ▶ 1D conv, Max pooling, and FC layers
- ▶ No batch normalization



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# Evaluation

## Comparison

- ▶ CNNs
- ▶ SVM, GBDT
- ▶ CNN feats + GBDT / SVM

# Evaluation

## Sensor selection

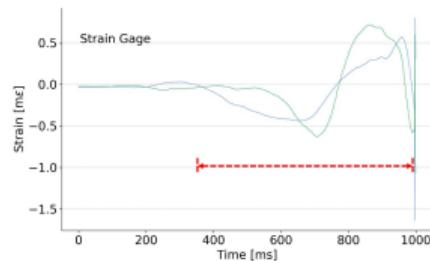
- ▶ SG + Acc. + Gyro. ( $8 \times 645$ )
- ▶ SG ( $2 \times 645$ )
- ▶ Acc. ( $3 \times 645$ )
- ▶ Gyro. ( $3 \times 645$ )

Jiao L, Bie R, Wu H, et al. Golf swing classification with multiple deep convolutional neural networks[J]. International Journal of Distributed Sensor Networks, 2018, 14(10).

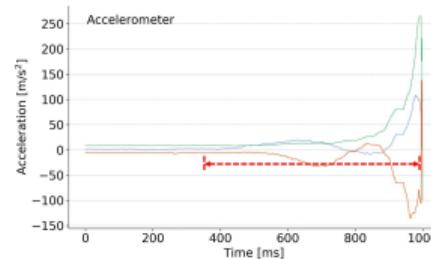
# Evaluation

## Real-time performance

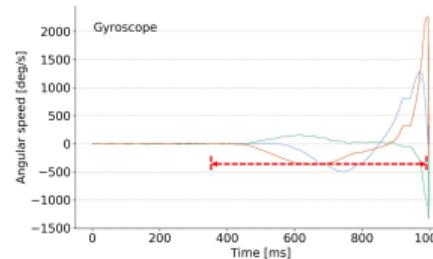
- ▶ 350 to 995 ( $8 \times 645$ , Default)
- ▶ 350 to 950 ( $8 \times 600$ ), 900 ( $8 \times 550$ ), 850 ( $8 \times 500$ ), and 800 ( $8 \times 450$ )



(a) SG



(b) Acc.



(c) Gyro.

图: Real-time performance test

Jiao L, Wu H, Bie R, et al. Towards Real-Time Multi-Sensor Golf Swing Classification Using Deep CNNs[J]. Journal of database management, 2018, 29(3):17-42.

谢 谢 大 家!