

# Direction-Free In-Air Signature Verification Using WIFI CSI Signal

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**Abstract.** The abstract should briefly summarize the contents of the paper in 15–250 words.

**Keywords:** First keyword · Second keyword · Another keyword.

## 1 Introduction

### 1.1 Motivation

i. Pros of In-Air WIFI CSI signature system 1) Cheap: Use commercial device  
2) Easy: No additional devices is needed 3) Secure: Hard to forgery ii. Cons  
of In-Air WIFI CSI signature system 1) Setting direction problem a) Different  
direction - Different feature is needed b) Hard to set exactly same direction as  
authentication before Size of signature can varies

### 1.2 Contribution

- Overcome cons of WIFI signature system - Robust to signal direction, size

## 2 Related Works

a. WIFI CSI b. Siamese Networks

### 2.1 WIFI CSI

- An In-Air Signature Verification System Using Wi-Fi Signals

### 2.2 Siamese Networks

i. Signature Verification using a "Siamese" Time Delay Neural Network Siamese  
Neural Networks for One-Shot Image Recognition

### 3 Proposed System

#### 3.1 Data Acquisition and Preprocessing

In this section, we introduce a system for recognition of Wi-Fi based in-air signature which utilizes the Siamese network learning for validation. An overview of the proposed scheme is shown in Fig.1.

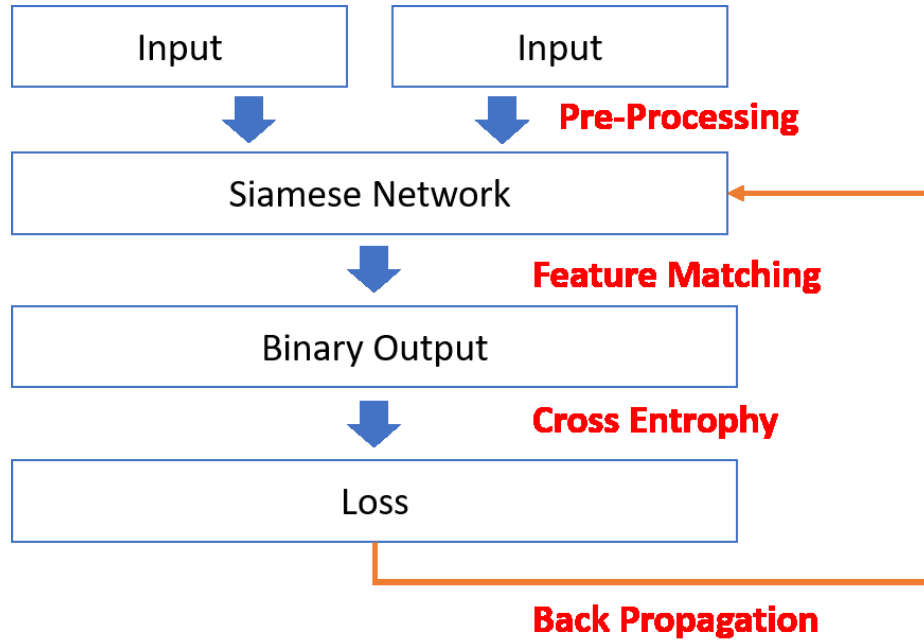


Fig. 1. ...

Two preprocessed signals enter the Siamese network and the network extracts non-directional characteristics from two signals and calculates how similar the two extracted characteristics are. The output of the Siamese network is 1 when the distance of the characteristic vector is close, and 0 when it is far. the network is learned by the back-propagation.

The main purpose of this system is to receive two csi signals as input, to determine if the two signals are the same signature. Since signals may differ in the direction in which they are entered, our system must be capable of extracting non-direction-related characteristics from two signals.

In order to be used as an input to a siamese network, the data must be pre-processed.

First, the signal have to converted to non-complex form. Since the Wi-Fi signature signals in CSI packets in 2.4Ghz has firmware issues in their phase[ref] we used absolute of signal only.

Second, all inputs must be arranged of same size. Since all signals have different length, the gradient operation with respect to the time instance is adopted to measure the short time energy. Data points with the highest short-time energy within the time period are regarded as the starting and the ending points of the in-air signature. And they are re-sampled uniformly based on Fast Fourier Transform (FFT) [16] to normalize the length of the data.

### 3.2 Siamese Network For Verification

The model receives two processed CSI signals as inputs, and outputs the probability that the two signals are of the same class as the output.

Even if a signal belongs to the same class, the shape of the input is very different if the signal is oriented differently. To classify regardless of the direction of the signal, the model shall be capable of extracting features unrelated to the direction.

### 3.3 Feature Extraction

When two processed signals come as the input, they are put to 2 symmetric CNN network.

Purpose of CNN is to extract features from signal. By sharing their feature map, this CNN networks is trainin to learn characteristics regardless of the direction only.

To perform the feature extraction, we firstly need to have a convolutional neural networks to serve as the feature extractor Based on the ConvNet structure [17] the feature extractor of the proposed pretraining model consists of  $i$  convolution layers and activation functions followed by  $i$  max-pooling layers. Each convolution layer has  $f$  filters to be trained, where  $i = 1, \dots, i$ . In a similar manner,  $j$  fully connected layers constitute the classifier of pretraining model where each layer has  $g_{\bullet}, (\bullet=1, \dots, j)$  neurons to be trained.

### 3.4 Feature Matching

Output of the CNN are feature vectors extracted from two samples. The Euclidean distance between the two features can be calculated. In the proposed system, this Euclidean distance is utilized to match between two feature vectors.

### 3.5 Loss and Backpropagation

We impose a regularized cross-entropy objective on our binary classifier. This objective is combined with standard backpropagation algorithm, where the gradient is additive across the twin networks due to the tied weights. We initialized

all network weights in the convolutional layers from a normal distribution with zero-mean and a standard deviation of 102. Biases were also initialized from a normal distribution, but with mean 0.5 and standard deviation 102.

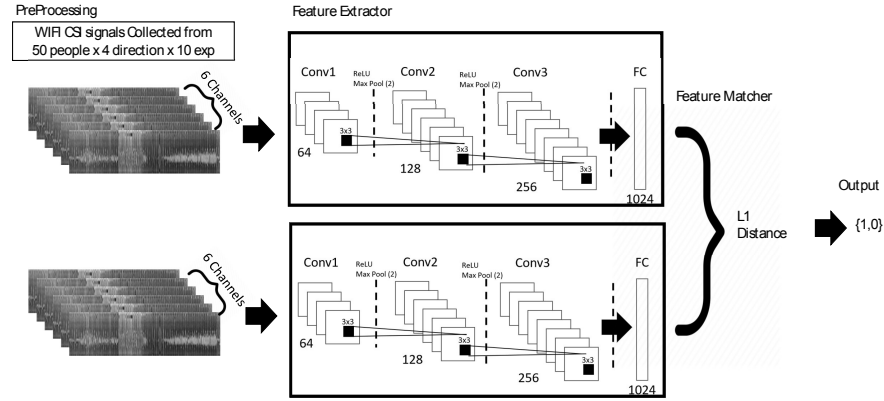


Fig. 2. ...

## 4 Experiments

## 5 Conclusion

## 6 \*\*\* Template \*\*\*

## 7 First Section

### 7.1 A Subsection Sample

Please note that the first paragraph of a section or subsection is not indented. The first paragraph that follows a table, figure, equation etc. does not need an indent, either.

Subsequent paragraphs, however, are indented.

**Sample Heading (Third Level)** Only two levels of headings should be numbered. Lower level headings remain unnumbered; they are formatted as run-in headings.

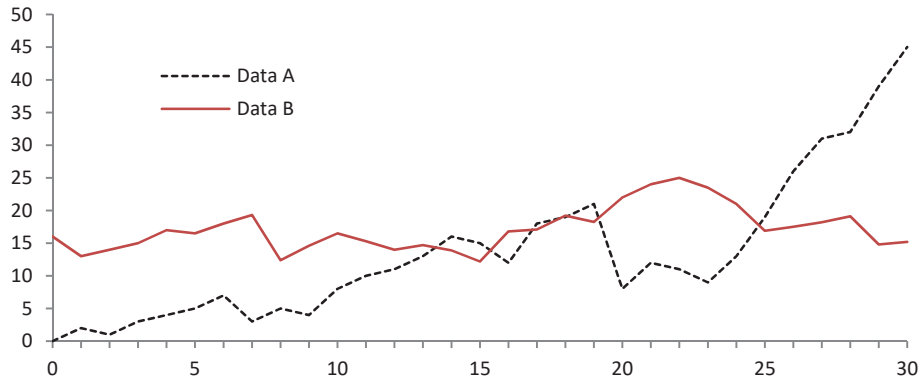
**Table 1.** Table captions should be placed above the tables.

Heading level	Example	Font size and style
Title (centered)	<b>Lecture Notes</b>	14 point, bold
1st-level heading	<b>1 Introduction</b>	12 point, bold
2nd-level heading	<b>2.1 Printing Area</b>	10 point, bold
3rd-level heading	<b>Run-in Heading in Bold.</b> Text follows	10 point, bold
4th-level heading	<i>Lowest Level Heading.</i> Text follows	10 point, italic

*Sample Heading (Fourth Level)* The contribution should contain no more than four levels of headings. Table ?? gives a summary of all heading levels. Displayed equations are centered and set on a separate line.

$$x + y = z \quad (1)$$

Please try to avoid rasterized images for line-art diagrams and schemas. Whenever possible, use vector graphics instead (see Fig. ??).



**Fig. 3.** A figure caption is always placed below the illustration. Please note that short captions are centered, while long ones are justified by the macro package automatically.

**Theorem 1.** *This is a sample theorem. The run-in heading is set in bold, while the following text appears in italics. Definitions, lemmas, propositions, and corollaries are styled the same way.*

*Proof.* Proofs, examples, and remarks have the initial word in italics, while the following text appears in normal font.

For citations of references, we prefer the use of square brackets and consecutive numbers. Citations using labels or the author/year convention are also acceptable. The following bibliography provides a sample reference list with entries for journal articles [?], an LNCS chapter [?], a book [?], proceedings without editors [?], and a homepage [?]. Multiple citations are grouped [?, ?, ?], [?, ?, ?, ?].

## References

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