**Summary:**

**Multimodal Biometrics for Usuable   
Authentication System Using a Smartphone**

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1. **Overview:**
   1. Singlemodal biometric for user authentication system
      1. Arm’s flex when responding call
      2. Ear biometrics
   2. Multimodal biometrics for user authentication system: arm’s flex and ear shape
2. **Problems and solutions:**
   1. User authentication using arm’s flex biometric

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| *Paper title* | Arm’s Flex when Responding Call for Implicit User Authentication in Smartphone |
| *Appeared in* | International Journal of Security and Its Applications 6(3), 2012 |
| *Data acquisition* | * *Mobile phone:* Pantech Sky Vega Racer * *Sensor:* accelerometer * 6 volunteers, 20 patterns of two categories ((1) phone picked from desk, and (2) phone picked from pocket) for each person |
| *Classification* | * *Template Matching method:* measuring similarity and thresholding * *Similarity =* (Euclidean distance score) / (Cosine similarity score) |
| *Result* | * ***Category 1:***   + *Classification accuracy = 87.8%*   + *False Match Rate (FMR) = 14%*   + *False Non-Match Rate (FNMR) = 3.3%* * ***Category 2:***   + *Classification accuracy = 90%*   + *False Match Rate (FMR) = 11.3%*   + *False Non-Match Rate (FNMR) = 3.3%* |

* 1. User authentication using ear biometric

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| *Paper title* | Implicit Authentication based on Ear Shape Biometrics using Smartphone Camera during a Call |
| *Appeared in* | International Conference on Systems, Man, and Cybernetics, IEEE, 2012 |
| *Data acquisition* | * *Mobile phone:* Samsung Galaxy S2 * 20 subjects, totally 80 images of size 1600x1200, cropped to 100x165 grayscale images |
| *Data preprocessing* | * Split each image into 4 quadrantal parts |
| *Feature extraction* | * Combining histogram resulted from Local Binary Pattern (LBP) and Geometric Analysis * 61 features are obtained |
| *Classification* | * kNN classifier |
| *Result* | * Classification rate = 92.5% |

* 1. Multimodal biometrics for authentication: arm’s flex and ear

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| *Paper title* | A Study on Multibiometrics derived from Calling Activity Context using Smartphone for Implicit User Authentication System |
| *Appeared in* | International Journal of Contents 9(2), 2013 |
| *Idea for combination* | First use arm’s flex, then use ear image when the phone is put near the ear in picking a call activity |
| *Data acquisition* | * *Mobile phones:* Samsung Galaxy S3, LG Optimus II, Pantech Sky Vega Racer * *Data source:* accelerometer, gyroscope, front camera |
| *Data preprocessing* | * **Arm flex:**   + Linear interpolation, noise filtering (2n+1-moving average filter) * **Ear image:**   + Divide ear image into four subregions |
| *Feature Extraction* | * **Arm flex:**   + Segmentation: fixed length of 250 * **Ear image:**   + Divide ear image into four subregions   + Combining histogram resulted from Local Binary Pattern (LBP) and Geometric Analysis |
| *Classification* | * **Arm flex:**   + *Template Matching* by using Dynamic Time Warping (DTW) distance measure (score in [0;1]) * **Ear image:**   + kNN classifier with Euclidean distance from histogram (score in [0;1])   + Summation of two distance score (in [0;2]) and thresholding with values |
| *Result* | * *Accuracy:*   + : 95%   + : 92.5%   + : 87.5% |

* 1. Thesis: Multimodal biometrics for authentication: arm’s flex and ear

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| *Title* | Multimodal Biometrics for Usuable Authentication System Using a Smartphone |
| *Idea for combination* | First use arm’s flex, then use ear image when the phone is put near the ear in picking a call activity |
| *Data acquisition* | * *Mobile phones:* Samsung Galaxy S3, LG Optimus II, Pantech Sky Vega Racer * *Accelerometer, gyroscope:* 30 persons, 300 data in total * *Front camera:* 30 persons, 300 images in total |
| *Data preprocessing* | * **Arm flex:**   + Linear interpolation, noise filtering (2n+1-moving average filter) * **Ear image:**   + Divide ear image into four subregions |
| *Feature extraction* | * **Arm flex:**   + Segmentation: fixed length of 250 * **Ear image:**   + Divide ear image into four subregions   + Combining histogram resulted from Local Binary Pattern (LBP) and Geometric Analysis, and Monogenic Local Binary Pattern (M-LBP) |
| *Classification* | * **Arm flex:**   + *Template Matching* by using Dynamic Time Warping (DTW) distance measure (score in [0;1]) * **Ear image:**   + kNN classifier with Euclidean distance from histogram (score in [0;1])   + Summation of two distance score (in [0;2]) and thresholding with values |
| *Result* | * *Accuracy:* 95% () * *Receiver Operating Characteristics (ROC) analysis:* calculate area under curve (AUC)   + AUC = 0.8731 for arm flex only   + AUC = 0.9218 for ear only   + *AUC* = 0.9301 when combined |