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| **TouchAnalytics [58][67][51]** | | | | | | |
| **5-Fold CV** | | | | | | |
| **Studio** | **Classificatore** | **Performance EER (%)** | | | | |
| [Frank et al. [58]](https://arxiv.org/pdf/1207.6231.pdf) | Intra-session kNN SVM | 2.0 - 3.0 % | | | | |
| Inter-session kNN SVM | 1. - 4.0 % | | | | |
| [Šeděnka et al. [67]](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6971118) |  | **No PCA** | | **PCA** | | |
| Scaled Manhattan | 21.3 % | | 18.3 % | | |
| Scaled Euclidean | 21.0 % | | 18.3 % | | |
| 1-Prob | 16.7 % | | 24.1 % | | |
| [Fierrez et al. [51]](http://atvs.ii.uam.es/atvs/files/2018_TIFS_TouchBio_Fierrez.pdf) |  | **Up** | **Down** | **Left** | **Right** | **All** |
| Intra-session (GMM+SVM) | 3.5 (4.9) % | 4.3 (3.5) % | 3.3 (3.2) % | 3.1 (3.0) % | / |
| Inter-session (GMM+SVM) | 8.1 (7.2) % | 8.4 (7.6) % | 10.2 (7.96) % | 12.8 (15.6) % | / |
| Combined sessions (GMM+SVM) | 5.9 (5.9) % | 5.2 (4.3) % | 3.1 (2.9) % | 3.8 (3.4) % | / |
| **Metodo Proposto**  **Oversampling**  **Downsampling** | Random Forest | 0.82 % | 0.67 % | 0.83 % | 0.54 % | 0.63 % |
| kNN | 24.71 % | 20.45 % | 21.3 % | 19.66 % | 19.57 % |
| SVM | 13.24 % | 23.35 % | 18.24 % | 21.6 % | 45.01 % |
| Neural Network | 9.26 %  (90.3 AUC) | 19.08 % | 8.63 % | 20.02 % | 16.23 % |

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| [**BioIdent [70]**](https://ms.sapientia.ro/~manyi/bioident.html)**[51]** | | | | | |
| 3-fold CV  Dataset 1 e 2 (User Identification) Dataset 3 [9 Maschi e 9 Femmine] (Gender identification)  Dataset 4 Touch **Experience Level classification (0-1-2-3)** | | | | | |
| **Studio** | **Classificatore** | **Performance Accuracy (%)** | | | |
|  |  | **Dataset 1 e 2** | **Dataset 3** | **Dataset 4** | |
| [Margit et al.](https://www.sciencedirect.com/science/article/pii/S0167865515000355)[70] | k-NN  D1-2-3(K=3) D4 (K=1) | 99 % | 88 % | 81% 1 Strokes  100 % 20 Strokes | |
| Random Forest  D1(T=10) D2-4(T=100) | 99 % | 88 % | 81% 1 Strokes  100 % 20 Strokes | |
| SVM RBF  D1-4(C=2, y=8) D2(C=8, y=8) | 99 % | 88 % | 81% 1 Strokes  100 % 20 Strokes | |
| **Metodo Proposto**  **Oversampling**  **Downsampling** | Random Forest  (T=100) | 99.87 |99.86 % | 86.75 % | 96.08 % | |  |
| 88.42 | 88.39 % | 86.11 % | 83.54 % | |
| KNN  (K=3) | 99.34 |99.37 % | 86.20 % | 91.68 % | |  |
| 84.34 | 83.95 % | 85.46 % | 83.68 % | |
| SVM RBF  D1-4(C=2, y=8) D2(C=8, y=8) | 99.16 |99.31 % | 89.53 % | 92.59 % | |  |
| 88.48 | 89.24 % | 88.79 % | 86.94 % | |
| Neural Network  D1-2(10 Epoche)  D3-4(100 Epoche) | 96.25 % ACC  (3.74 % EER) | 85.06 % ACC  (14.93 % EER) | 91.55 % ACC  (8.4 % EER) | |  |
| 88.35 % ACC  (11.64 % EER) | 86.80 % ACC  (13.19 % EER) | 80.96 % ACC  (19.03 % EER) | |
|  | | | | | |
|  |  | **Dataset 1 (EER %)** | | | |
|  |  | **Up** | **Down** | **Left** | **Right** |
| [Fierrez et al. [51]](http://atvs.ii.uam.es/atvs/files/2018_TIFS_TouchBio_Fierrez.pdf) | GMM+SVM | 1.8 % | 2.6 % | 5.3 % | 8.2 % |
| **Metodo Proposto**  **Oversampling** | Random Forest | 1.7 % | 2.0 % | 4.8 % | 9.4 % |
| KNN (K=3) | 8.6 % | 9.8 % | 6.3 % | 8.9 % |
| SVM (C=2, y=8) | 6.0 % | 5.0 % | 8.9 % | 8.4 % |
| Neural Network  (10 Epoche) | 3.25 % | 2.8 % | 3.8 % | 3.61 % |

**n order to find the differences between male and female users Wilcoxon signed-rank test (0.05 significance level) was performedfor all the 15 attributes involved in classification.**

**No differences werefound for the following attributes:**

startX, upDownLeftRight, largest-DeviationFromEndToEndLine, averageVelocity and midStrokeArea.

**The most significant differences were found at the following at-tributes (in decreasing order):**

startY, stopY, directEndToEndDistance,lengthOfTrajectory, meanResultantLength, strokeDuration, direc-tionOfEndToEndLine, stopX, midStrokePressure, averageDirection.

**men tend to make shorter and less straight strokesthan women.**

**F. [51] …. and horizontal gestures are more discriminative in general than vertical ones.**

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| **The MobiKey [31][21]** | | | | | |
| **[Classe in esame] vs [10foldCV su esempi random da tutti gli altri utenti]** | | | | | |
| **Studio** | **Classificatore** | **Performance EER (%)** | | | |
| [Antal et al. [31]](https://link.springer.com/chapter/10.1007/978-3-319-33622-0_4) |  | **Features** | **Easy** | **Logical strong** | **Strong** |
| Bayes net | All | 5.3 % | 4.6 % | 4.9 % |
| kNN (k = 1) | All | 7.3 % | 6.8 % | 7.1 % |
| Random forests (T = 100) | All | 3.2 % | 3.3 % | 3.3 % |
| Euclidean | All | 23.8 % | 18.3 % | 19.5 % |
| Manhattan | All | 20.3 % | 15.4 % | 16.7 % |
| Mahalanobis | All | 25.6 % | 19.3 % | 21.0 % |
| Outlier count (th = 1.96) | All | 16.0 % | 12.9 % | 14.3 % |
| Kmeans (k = 3) | All | 17.3 % | 12.8 % | 13.1 % |
| Kmeans (k = 3) | Secondorder | 17.7 % | 13.6 % | 14.3 % |
| Bayes net | Secondorder | 7.4 % | 5.8 % | 6.7 % |
| kNN (k = 1) | Secondorder | 5.6 % | 4.8 % | 5.4 % |
| Random forests (T = 100) | Secondorder | 5.2 % | 4.5 % | 5.1 % |
| Euclidean | Secondorder | 20.8 % | 14.9 % | 18.1 % |
| Manhattan | Secondorder | 20.2 % | 14.4 % | 16.9 % |
| Mahalanobis | Secondorder | 19.1 % | 15.4 % | 15.9 % |
| Outlier count (th = 1.96) | Secondorder | 20.8 % | 16.4 % | 17.8 % |
| [Kalita et al. [21]](https://ieeexplore.ieee.org/abstract/document/9163524) | GMM | All | / | 2.34 % | / |
| **Metodo Proposto**  **Oversampling**  **Downsampling** | Random Forest  (T = 100) | All | 0.02 % | 0.04 % | 0.03 % |
| All | 4.98 % | 5.18 % | 4.15 % |
| kNN  (k = 1) | All | 0.45 % | 0.65 % | 0.61 % |
| All | 16.97 % | 24.02 % | 20.7 % |
| SVM  (C=2, gamma=8) | All | 0.01 % | 0.01 % | 0.01 % |
| All | 50.00 % | 50.00 % | 50.00 % |
| Neural Network  (300 Nodes, 10 Epochs) | All | 1.66 % | 2.29 % | 2.20 % |
| All | 14.00 % | 17.58 % | 20.75 % |
| Random Forest  (T = 100) | Secondorder | 0.16 % | 0.13 % | 0.14 % |
| Secondorder | 7.26 % | 6.49 % | 5.89 % |
| kNN  (k = 1) | Secondorder | 0.88 % | 0.89 % | 0.89 % |
| Secondorder | 31.28 % | 33.92 % | 33.52 % |
| SVM  (C=2, gamma=8) | Secondorder | 0.01 % | 0.01 % | 0.01 % |
| Secondorder | 47.39 % | 48.45 % | 48.34 % |
| Neural Network  (300 Nodes, 10 Epochs) | Secondorder | 20.71 % | 22.63 % | 1.88 % |
| Secondorder | 45.87 % | 45.53 % | 18.02 % |

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| **Weka Arff[68][69]** | | | | | |
| **[Classe in esame] vs [10-foldCV su esempi random da tutti gli altri utenti] 90% Train e 10% Test**  **Dataset 3 = these three features are password independent (meanholdtime, meanpressure and meanfingerarea) and reflect the users' individual characteristics** | | | | | |
| **Studio** | **Classificatore** | **Performance EER (%)** | | | |
|  | / | **71 Features** | **17 Features** | | **3 Features** |
| [Szabo et al [68]](https://ieeexplore.ieee.org/document/7168452?arnumber=7168452&punumber%3D7158222%26filter%3DAND(p_IS_Number:7168393)%26pageNumber%3D3=)  2 Class classif. | Bayesan Network (Default) | 4.3 % | 6.6-10.9 % | | 7.1-9.8 % |
| kNN (k=3) | 8.3 % | 6.6-10.9 % | | 7.1-9.8 % |
| Random Forest (T = 100) | 3.1 % | 6.6-10.9 % | | 7.1-9.8 % |
| **Metodo Proposto**  **Oversampling**  **Downsampling** | Random Forest (T=100, BootStrap=0.5, Rand=”sqrt”) | 0.08 % | 0.32 % | | 0.60 % |
| 4.38 % | 7.76 % | | 7.09 % |
| KNN (K=3) | 0.72 % | 1.04 % | | 0.91 % |
| 8.61 % | 10.47 % | | 7.52 % |
| SVM (Linear) | 2.84 % | 8.07 % | | 12.05 % |
| 8.04 % | 11.17 % | | 14.00 % |
| Neural Network (AVG 10 Epoche per Classe vs ALL) | 0.82% (99.17 Acc)  / | 3.15% (96.84 Acc)  / | | 8.25% (91.74 Acc)  / |
|  | | | | | |
| [Szabo et al [68]](https://ieeexplore.ieee.org/document/7168452?arnumber=7168452&punumber%3D7158222%26filter%3DAND(p_IS_Number:7168393)%26pageNumber%3D3=)  **1 Class classification**  The fraction of rejected objects on the positive class was set to 0.1. | default optimization for the width parameter of the parzendd | 18-19% | / | | 7% with 1% confidence bound |
| k≃3 for the knndd |
| 2 mixtures for the mogdd |
|  |  |  |  | |  |
|  | | | | | |
|  |  | **Accuracy (%)** | | | |
| [Laszlo et al [69]](https://ms.sapientia.ro/~manyi/research/KeyStrokeDynamicsPaperFinal.pdf) | / | **41 Features** | | **71 Features** | |
| Naive Bayes | 50.15 % | | 78.93 % | |
| Bayesan Network | 75.95 % | | 91.94 % | |
| C4.5 (J48) (confidence 0.2, minimum for istances for leaf) | 54.79 % | | 69.02 % | |
| kNN (K=1) | 41.07 % | | 72.98 % | |
| SVM 41F (C=10.55, gamma=1.86)  71F (C=7.46, gamma=0.25) | 61.71 % | | 88.33 % | |
| Random Forest (T=100) | 82.53 % | | 93.04 % | |
| MLP [hidden layer = (# attributes +classi) /2] | 53.01 % | | 86.26 % | |
| **Metodo Proposto**  **Oversampling**  **Downsampling** | Random Forest  (T=100, BootStrap=0.5, Rand =”sqrt”) | 99.92 % | | 99.81 % | |
| 95.73 % | | 93.32 % | |
| KNN (K=3) | 98.42 % | | 98.42 % | |
| 78.57 % | | 77.21 % | |
| SVM 41F (C=10.55, gamma=1.86)  71F (C=7.46, gamma=0.25) | 96.07 % | | 91.99 % | |
| 81.27 % | | 78.98 % | |
| Neural Network  (AVG 10 Epoche per Classe vs ALL) | 98.07 % | | 98.30 % | |
| / | | / | |