Hidden Biometric Modalities

A Comprehensive Survey of Emerging Techniques and Applications

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Outline

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Introduction

What are Hidden Biometrics?

Definition

Hidden biometrics use physiological and behavioral signals **inherently resistant to spoofing** for identity verification.

Why Hidden?

- Not visible/observable
- Cannot be replicated
- Difficult to steal
- High security level

Key Advantages

- Spoofing resistant
- Continuous availability
- Unique signatures
- Non-invasive

Survey Overview

Signal-Based:

1. **DNA** - Genetic code
2. **ECG** - Heart electrical activity
3. **EEG** - Brain electrical activity
4. **EMG** - Muscle electrical activity

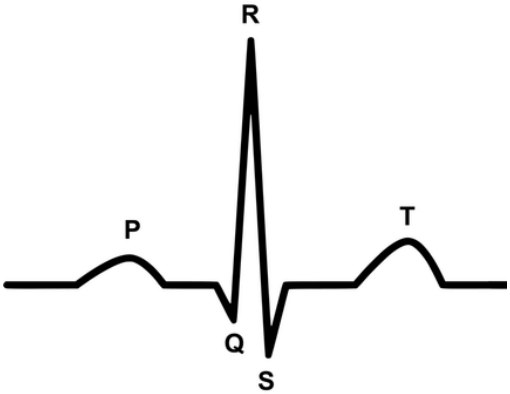
Imaging-Based:

1. **MRI** - Structural imaging
2. **X-ray** - Skeletal structure
3. **CT/PET** - Advanced imaging

Novelty: Integrated treatment of both signal-processing and image-based modalities

Key Modalities

ECG: Most Promising Modality



Advantages:

- Continuous monitoring
- Non-invasive acquisition
- Unique cardiac anatomy
- Simple sensors (fingers)

Performance:

- Fiducial: up to 100%
- Non-fiducial: 96-100%
- Databases: 1000+ subjects

DNA, EEG & EMG

DNA

- Permanent identifier
- Two techniques:
  - Genotyping
  - Phenotyping
- Perfect uniqueness
- High cost

EEG

- Brain signals
- Multiple bands:
  - α (8-13 Hz)
  - β (>14 Hz)
  - δ, θ
- Cognitive traits
- Limited databases

EMG

- Muscle signals
- Motor patterns
- Gesture recognition
- Low cost
- Fast acquisition

Medical Imaging

MRI & X-ray for Biometric Authentication:

MRI:

- Brain anatomy uniqueness
- No ionizing radiation
- High soft tissue contrast
- Excellent accuracy (>99%)
- High cost and time

X-ray:

- Skeletal structure
- Quick acquisition
- High resolution
- Reliable performance
- Ionizing radiation concern

Best for: High-security applications (border control, forensics)

Comparative Analysis

Quality Metrics Comparison

Property	DNA	ECG	EEG	EMG	MRI
Universality	H	H	M	M	H
Uniqueness	VH	H	H	H	VH
Permanence	Perm	M	M	L	H
Spoofing Resist.	E	G	G	F	E
Performance	G	VG	G	F	E
Cost	VH	L-M	M	L	VH

H=High, VH=Very High, E=Excellent, G=Good, F=Fair, L=Low, M=Medium, Perm=Permanent

Performance Results:

- DNA: Perfect identification in forensics
- ECG: 100% accuracy in controlled studies
- EEG: 98-99% with sufficient training data
- EMG: 95-99% for gesture recognition

Applications & Use Cases

Modality	Best Applications
DNA	Forensics, paternity, criminal databases
ECG	Healthcare, wearables, patient monitoring
EEG	Mental state verification, security
EMG	Gesture recognition, accessibility
MRI	High-security, medical authentication
X-ray	Border security, airports, rapid screening

Challenges & Future

Current Challenges

- **Databases**: Limited public datasets, standardization needed
- **Temporal Variation**: Signals change with age, health, stress
- **Cost**: High equipment costs (especially MRI)
- **Integration**: Gap between lab results and real-world deployment
- **Standardization**: Different protocols across studies
- **User Acceptance**: Privacy concerns and comfort

Future Directions

Key Research Opportunities:

Technical:

- Multi-modal fusion
- Deep learning integration
- Real-time processing
- Wearable sensors

Practical:

- Healthcare security
- IoT authentication
- Border control
- Financial services

Priority: Establish ISO standards and public databases

Conclusion

Key Takeaways

Summary

Hidden biometrics offer superior security through non-replicable physiological signals.

Main Points:

- **Diversity**: Multiple modalities for different security levels
- **ECG**: Most practical with excellent performance and low cost
- **Accuracy**: Competitive with conventional biometrics (95-100%)
- **Security**: Inherent spoofing resistance
- **Future**: Standardization and multi-modal systems will drive adoption