



Face Recognition and Its Applications

Frank Yeong-Sung Lin

**Department of Information Management
National Taiwan University**

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Outline

- ▶ Introduction to biometrics
- ▶ Introduction to face recognition
- ▶ Integration of face recognition with motion sensing technologies
- ▶ Sample applications
- ▶ Summary and conclusions



Introduction to Biometrics

▶ Needs

- ▶ Concept of CIA (Confidentiality, Integrity and **Availability** – to **authenticated** personnel with **authorized** service)
- ▶ From “(i) what you have” to “(ii) what you know about” and eventually to “(iii) who you really are”
- ▶ Market size: 5 to 10 billion (USD) from 2012 to 2017 with CAGR 12.9%



Introduction to Biometrics (cont'd)

▶ Criteria

- ▶ Uniqueness
- ▶ Universality
- ▶ User friendliness
- ▶ Permanence
- ▶ Measurability
- ▶ Acceptance
- ▶ Circumvention

▶ Modes

- ▶ One-to-one verification (authentication) vs. one-to-many recognition (identification)
- ▶ Uni-modal vs. multi-modal authentication



Introduction to Face Recognition

- ▶ Market trend
- ▶ Challenges
- ▶ Techniques
- ▶ Recent improvements
- ▶ Dimensions of applications
 - ▶ Security
 - ▶ Business
 - ▶ Entertainment
 - ▶ Life style
- ▶ Related technologies and associated applications

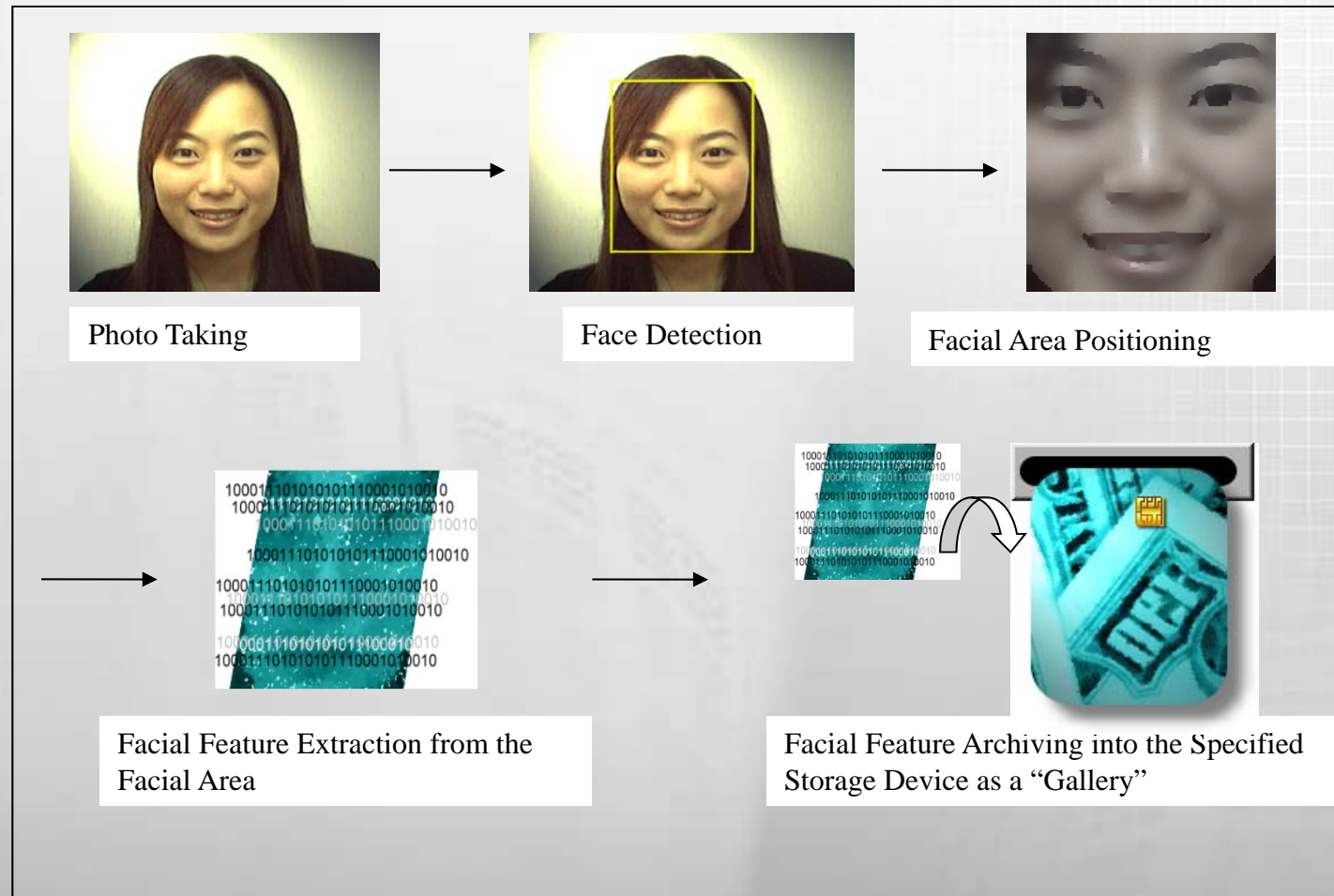


Introduction to Face Recognition (cont'd)

- ▶ Characteristics of desirable face verification technologies
 - Suitability for PCs/NBs/UMPCs/PDAs/Mobile Phones
 - Insensitivity to lighting, pose, expression and accessory variations
 - Visible and IR light versions
 - Low enrollment time
 - Low verification time
 - User adjustable and personalized sensitivity
 - Dynamic thresholding
 - Intelligent and self-learning galleries
 - **Factuality/Liveness detection**
 - Recognition of mirror images
 - Extremely high accuracy: e.g. product of FAR (False Acceptance Rate) & FRR (False Rejection Rate) lower than 10^{-6}
 - Integration with other, e.g., the credential (ID and password) mechanism

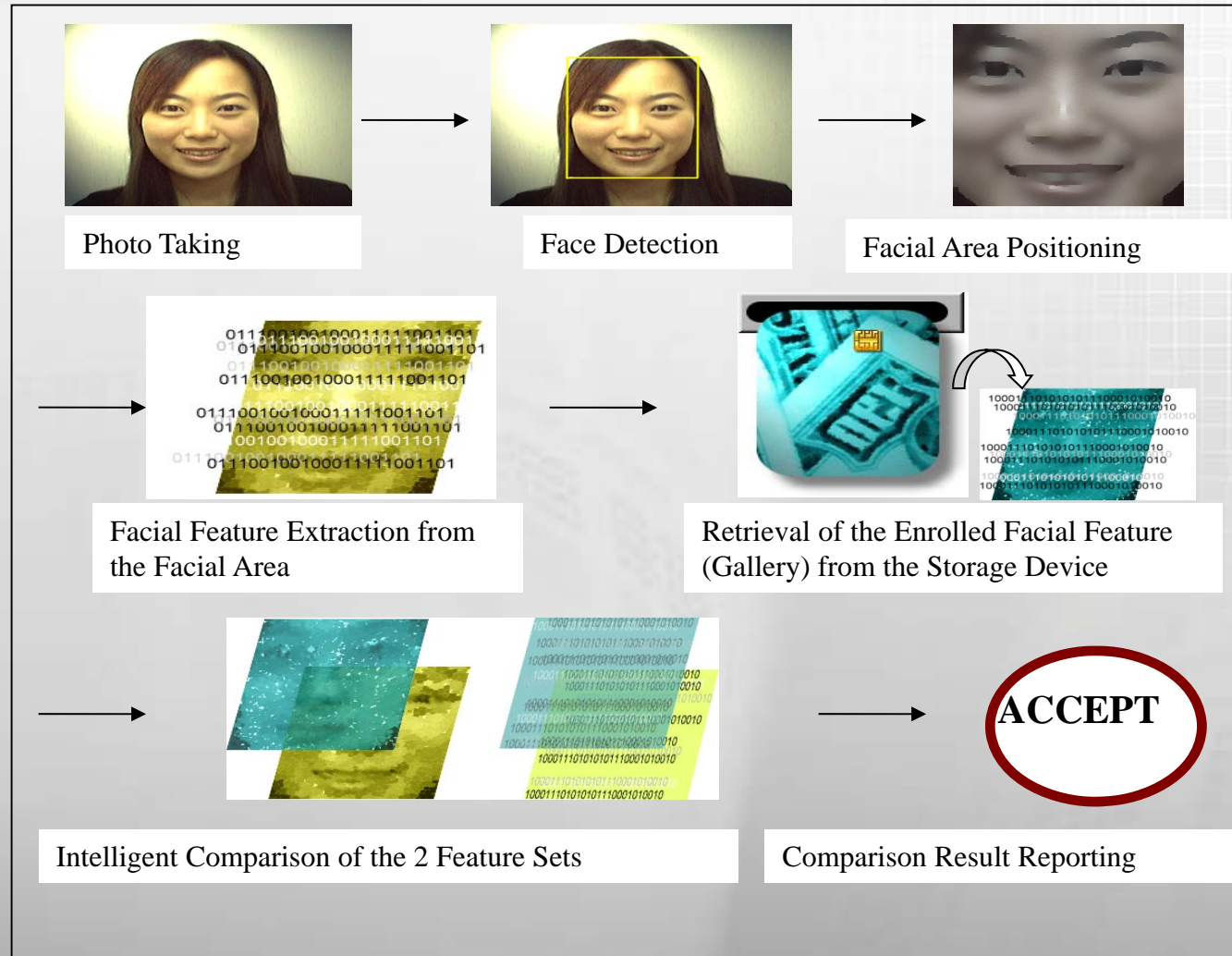
Introduction to Face Recognition (cont'd)

The Facial Feature Enrollment Process



Introduction to Face Recognition (cont'd)

The Facial Feature Verification Process





Introduction to Face Recognition (cont'd)

- ▶ Advantages of face-based over other, e.g., fingerprint-based biometric approaches
 - ▶ More convenient
 - ▶ Less intrusive
 - ▶ More hygienic
 - ▶ Leveraging on existing infrastructure (webcam)
 - ▶ Less prone to duplicate (fingerprints easily available on protected devices, e.g. NBs)
 - ▶ Capable of continuous verification
 - ▶ Verifiability by human eyes
 - ▶ Effects of deterrence and non-repudiation by logging probe/novel images
 - ▶ With potential applications other than security related ones

Introduction to Face Recognition (con'd)

Biometric Types Defined by ICAO (International Civil Aviation Organization)

First choice

Table 4 – Biometric Type

Field Value Name	Biometric Type Value
Multiple Biometrics Used	0x01
Facial Features	0x02
Voice	0x04
Fingerprint	0x08
Iris	0x10
Retina	0x20
Hand Geometry	0x40
Signature Dynamics	0x80
Keystroke Dynamics	0x100
Lip Movement	0x200
Thermal Face Image	0x400
Thermal Hand Image	0x800
Gait	0x1000
Body Odor	0x2000
DNA	0x4000
Ear Shape	0x8000
Finger Geometry	0x010000
Palm Geometry	0x020000
Vein Pattern	0x040000



Integration of Face Recognition with Motion Sensing Technologies

- ▶ Using Asus Xtion Pro/Live as an example of motion sensors
- ▶ Synergy by nature
 - ▶ Importance of user authentication and/or identification
 - ▶ Face, palm/hand/arm and body being all commonly used for expressions of commands/demands
 - ▶ Built-in cams
 - ▶ Through expansion of middleware



Integration of Face Recognition with Motion Sensing Technologies (cont'd)

▶ Features to be considered

▶ Face recognition (3D)

- ▶ Authentication with effective liveness/factuality detection
- ▶ Convenience/Personalization
- ▶ Controller recognition
- ▶ User tracking
- ▶ Assistance to skeleton tracking

▶ Face-based motion control (3D)

- ▶ Face tracking
- ▶ Pose tracking
- ▶ Gaze estimation
- ▶ Face landmark tracking and/or configuration analysis
- ▶ Expression detection



Integration of Face Recognition with Motion Sensing Technologies (cont'd)

- ▶ Features to be considered (cont'd)

- ▶ Demographic analysis (3D)

- ▶ Gender
 - ▶ Age
 - ▶ Ethnicity

- ▶ Other biometrics (3D)

- ▶ Gesture/Posture recognition
 - ▶ Gait recognition
 - ▶ Skeleton recognition



Sample Applications

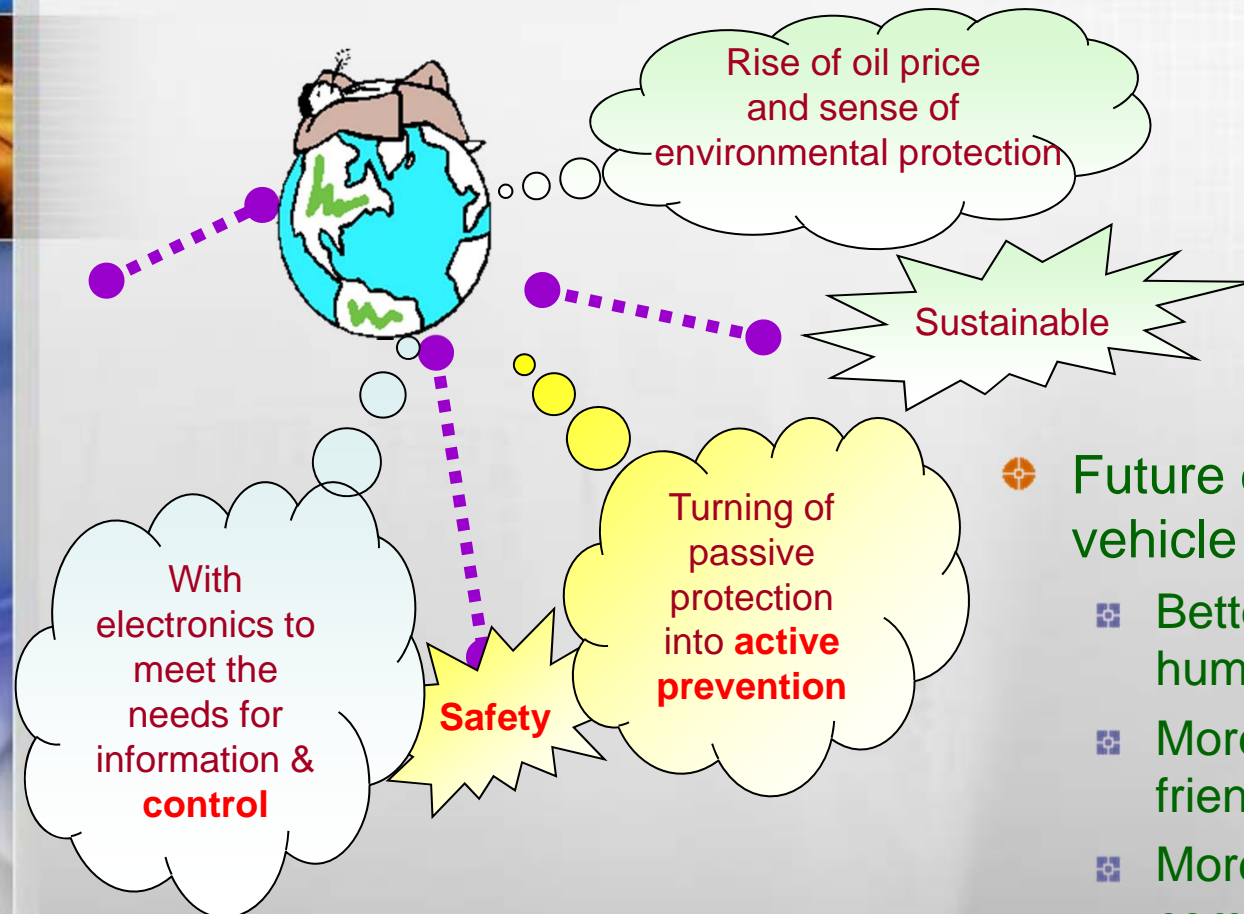
- ▶ Smart Logon, Smart Gate and Smart TAM (3D face recognition with effective liveness/factuality detection)
- ▶ Smart Proctor (3D face recognition with effective liveness/factuality detection for distance learning or on-line (motion-sensing) games)
- ▶ Smart Guard (3D occlusion detection with effective liveness/factuality detection for ATMs, banks and convenience stores)
- ▶ Smart TV (3D gesture recognition with 3D face recognition and 3D demographic analysis)
- ▶ Smart Signage (3D gesture recognition with 3D demographic analysis)
- ▶ Smart Car - Advanced Vehicle Safety and Security System (AVS³)



Smart Signage

- ▶ People counting and viewing time measurement (may also be used in the appraisal process)
- ▶ Face recognition adopted to prevent from multi-counting of the same person
- ▶ Demographic analyses
- ▶ Gesture recognition for user interaction
- ▶ Learning capabilities
- ▶ Real-time
- ▶ Multi-face recognition
- ▶ Comprehensive logs
- ▶ Watch list support
- ▶ VIP list support

Advanced Vehicle Safety and Security System (AVS³)



- Future direction for vehicle industry
 - Better protection of human lives
 - More environmentally friendly vehicles
 - More provision of comfort and convenience on wheels



Features of AVS³

- ▶ Security
 - ▶ Face-based driver identity recognition before ignition
 - ▶ Face-based driver identity recognition along driving
 - ▶ Multi-driver support
 - ▶ Robust and effective illumination control
- ▶ Safety
 - ▶ Fatigue/Drowsiness detection
 - ▶ Eye closure detection
 - ▶ Nodding detection
 - ▶ Face/Concentration detection
 - ▶ Gaze/Pose detection (for automatic headlight beam direction/width/intensity adjustment upon turns of heads)
 - ▶ Real-time monitoring
- ▶ Convenience/Personalization
 - ▶ Personal greetings upon positive recognition
 - ▶ Automatic personal ergo and environment setting adjustment
- ▶ Control
 - ▶ Gesture
 - ▶ Face
 - ▶ Voice



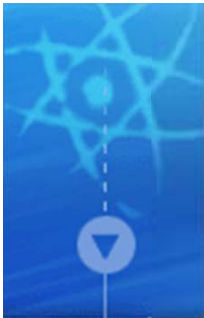
Characteristics of AVS³

- ▶ Operating at IR spectrum
 - ▶ to circumvent interference from visible light
 - ▶ to have minimum impact from sun light
 - ▶ to provide adequate illumination in the dark/night
 - ▶ to avoid interference to the driver (IR light being invisible)
- ▶ Continuous verification and monitoring without interference with the driver (unique advantage of face-based biometrics)
- ▶ Extremely efficient and effective liveness/factuality detection mechanism associated with the IR and 3D approach
- ▶ High accuracy of the IR-based 3D face recognition mechanism
- ▶ Face and motion sensing based control
- ▶ Multi-driver support



Summary and Conclusion

- ▶ A brief introduction to biometrics was given.
- ▶ Various aspects of face recognition were discussed.
- ▶ Advantages of integrating face recognition with existing motion sensing technologies were highlighted.
- ▶ A number of potential applications based upon the aforementioned integration were proposed.
- ▶ Motion sensing is a ground-breaking revolution for human-machine-interface (HMI) technologies, which would become even more powerful and effective via an integration with the face recognition technology.



Thank you!

Q&A