Quality Measures and Stacking Classifiers in Multimodal Biometric Recognition

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INTERACTIVE MULTIMODAL INFORMATION MANAGEMENT

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

BIOMETRICS CENTER

Outline

- IM2 MPR References
- Generalities
- Data and Metadata Quality
- Q-stack Model
- Aging Influence on Face Classifiers
- Q-stack Aging Model
- Experiments in Aging Face Verification
  - YouTube Data
  - MORPH Data
- Conclusions

IM2 MPR References

- K. Kryszczuk, J. Richiardi, A. Drygajlo, J. Kittler, "**Quality and Reliability in Biometrics**", Springer, 2009, Book to be published.

- K. Kryszczuk, A. Drygajlo, "**Improving biometric verification with class-independent quality information**", IET Signal Processing, Special Issue on Biometric Recognition, vol. 3, issue 4, 2009, pp. 310-321.

- K. Kryszczuk, J. Richiardi, A. Drygajlo, "**Impact of combining quality measures on biometric sample matching**", IEEE Third International Conference on Biometrics: Theory, Applications and Systems (BTAS 09), Washington DC, USA, September 28-30, 2009.

- K. Kryszczuk, A. Drygajlo, "**What do quality measures predict in biometrics**", 16th European Signal Processing Conference (Eusipco 2008), Lausanne, Switzerland, August 25-29, 2008.

- K. Kryszczuk, A. Drygajlo, "**On quality of quality measures for classification**", in B. Schouten, N.Ch. Juul, A. Drygajlo, M. Tistarelli (Eds) "Biometrics and Identity Management (BIOID 2008)", Lecture Notes in Computer Science 5372. Springer, 2008, pp. 19-28.

IM2 MPR References

- K. Kryszczuk "**Classification with class-independent quality information for biometric verification**", Ph.D. Thesis, EPFL, Advisor: A. Drygajlo, 2007.

- J. Richiardi "**Probabilistic models for multi-classifier biometric authentication using quality measures**", Ph.D. Thesis, EPFL, Advisor: A. Drygajlo, 2007.

- K. Kryszczuk, A. Drygajlo, "**Improving classification with class-independent quality measures: Q-stack in face verification**", 2nd International Conference on Biometrics (ICB 2007). Seoul, Korea, 27-29 August 2007.

- J. Richiardi, K. Kryszczuk, A. Drygajlo, "**Quality measures in unimodal and multimodal biometric verification**", Special Session "Multimodal Biometrics and Smart Cards", 15th European Signal Processing Conference, Poznan, Poland, Sept. 4-8, 2007

- K. Kryszczuk, A. Drygajlo, "**Q−stack: uni- and multimodal classifier stacking with quality measures**", 7th International Workshop on Multiple Classifier Systems 2007, Prague, Czech Republic, 2007.

IM2 MPR References

- A. Drygajlo, W. Li, K. Zhu, "**Q-stack Aging Model for Face Verification**", 17th European Signal Processing Conference (Eusipco 2009), Glasgow, Scotland, 24-28 Aug. 2009, pp. 65-69.

- A. Drygajlo, W. Li, K. Zhu, "**Verification of Aging Faces using Local Ternary Patterns and Q-stack Classifier**", International Conference on Biometric ID Management and Multimodal Communication (BioID_MultiComm09), Madrid, Spain, September 16-18, 2009.

- W. Li, A. Drygajlo, "**Identification of Aging Faces using A-stack Classification Model**", 2nd International Conference on Image and Signal Processing (CISP'09), Tianjin, China.

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Data Drift Causes

- Pattern recognition systems are often affected by sensor, object and environment changes such as
  - Illumination
  - Bacground noise
  - Objects pose/camera view point
  - Natural variability
  - Noise
  - Blurring
  - Sensor drift
  - Preprocessing algorithm errors

Prudent and Quality-based Designs

- Invariant features
- Normalisation
- Adaptation
- Multiple expert fusion
  - Fusion stage adaptation
- Postprocessing
  - Similarity score normalisation

- Quality-based algorithms
  - Q-stack: quality-based stacking classifier

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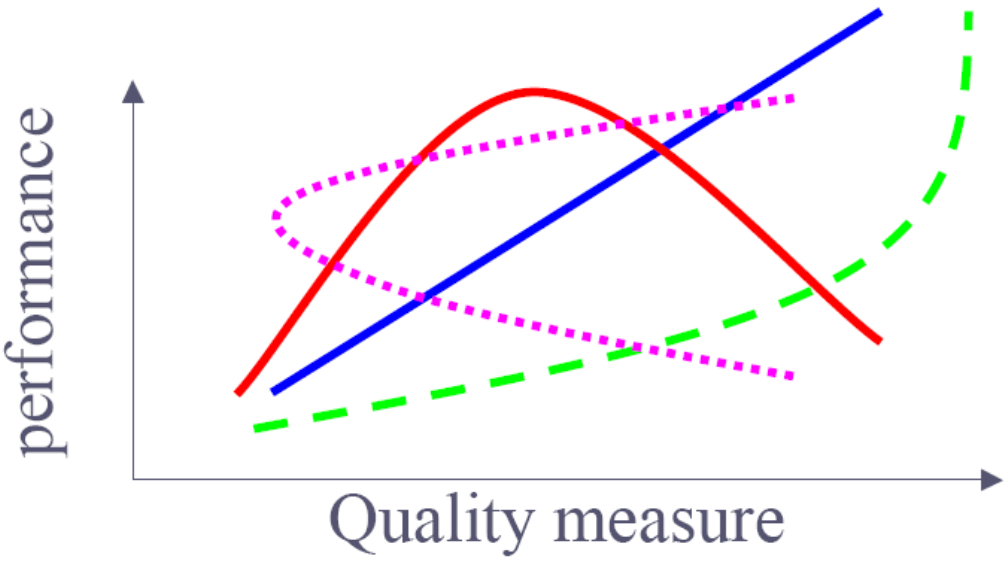
- **Data quality** – objective measure of the data departure from its nominal characteristic
  - Quality of samples
- **Metadata quality** – information associated with samples (e.g. age)
- Each quality measure is capable of measuring only one aspect of the data (signal) quality

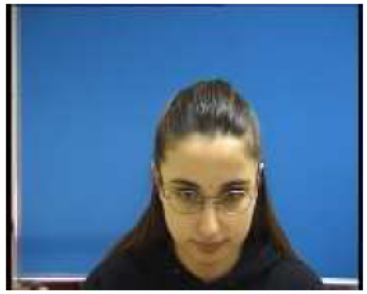


A data driven approach: If a relationship exists, a learning algorithm should be able to model it

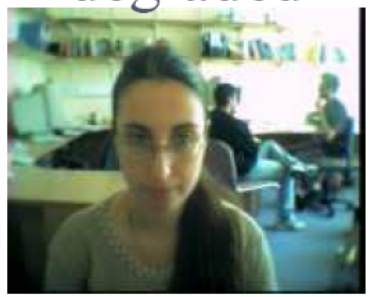
Face Quality Measures (Omniperception)

Q

conrolled



degraded



adverse

The 14 quality measures examined:

q

- Reliability
- Brightness
- Contrast
- Focus
- Bits per pixel
- Spatial resolution
- Illumination
- Background uniformity
- Background brightness
- Reflection
- Frontal quality
- In-plane rotation
- In-depth rotation
- Presence of glasses

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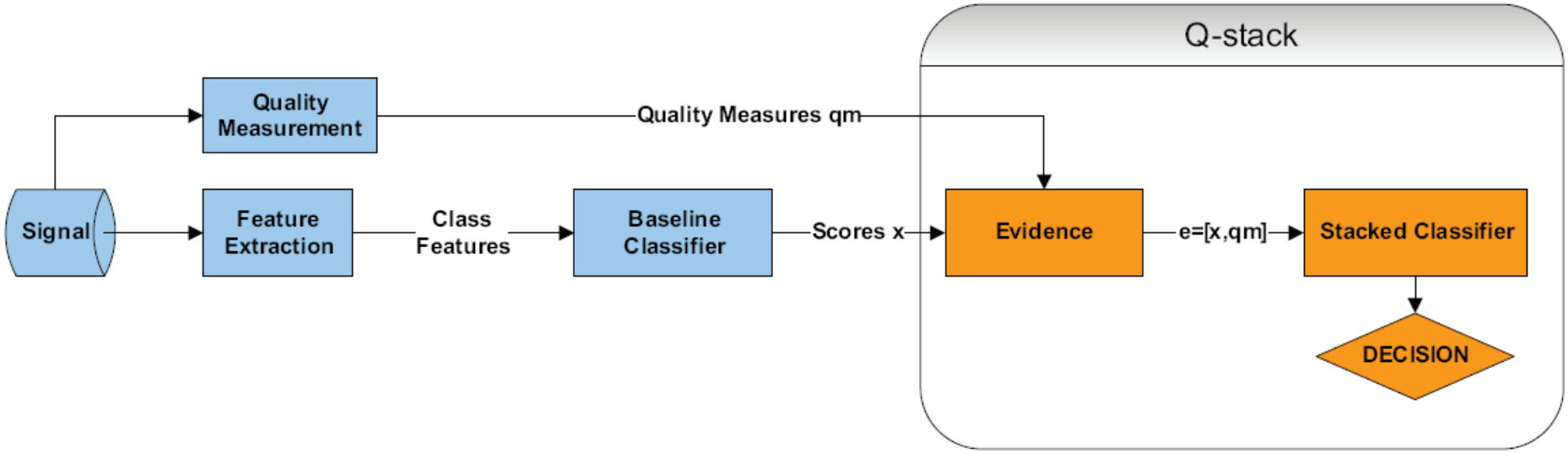
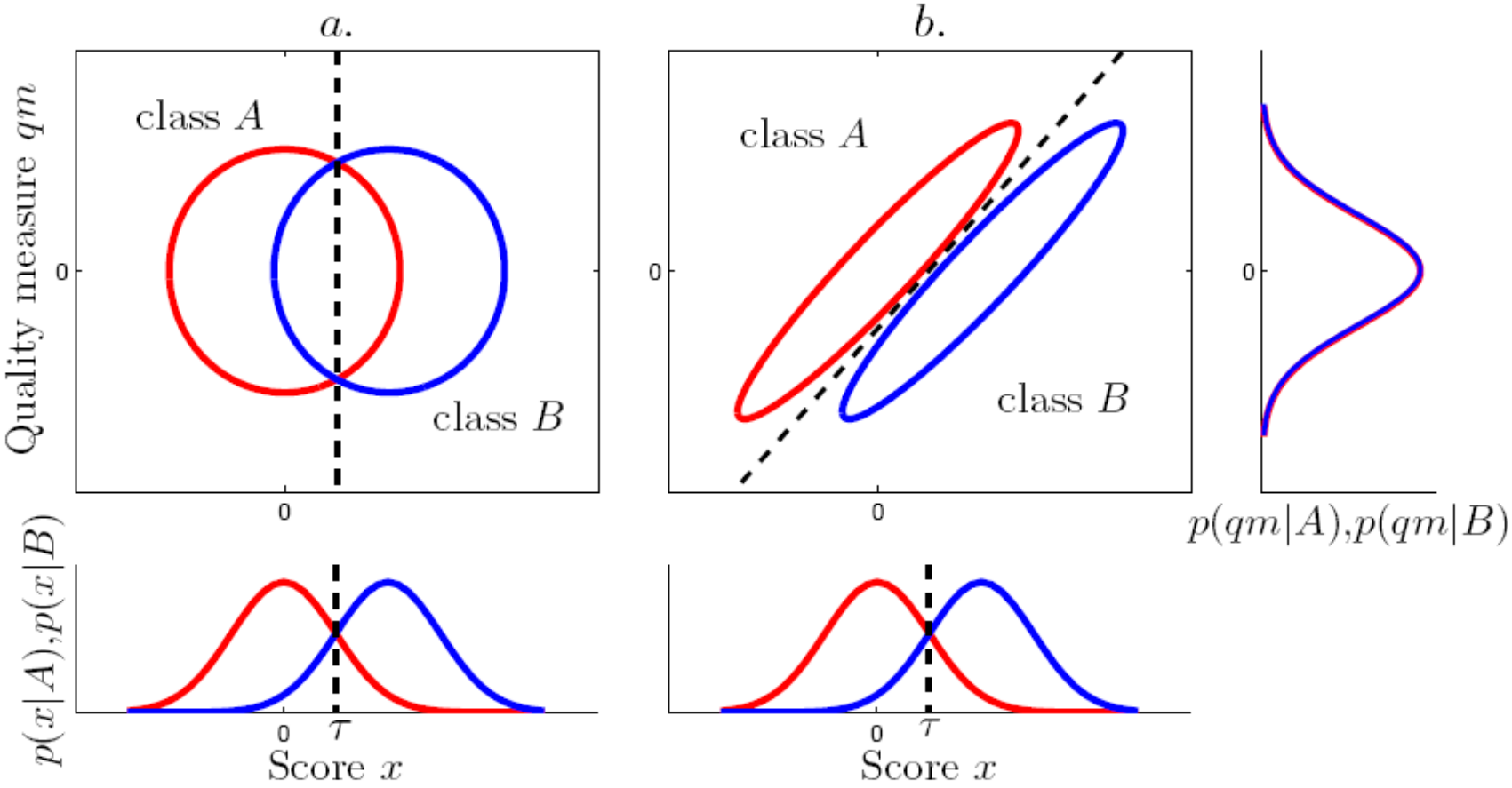
How to use quality measures?

Quality Measure
of Samples

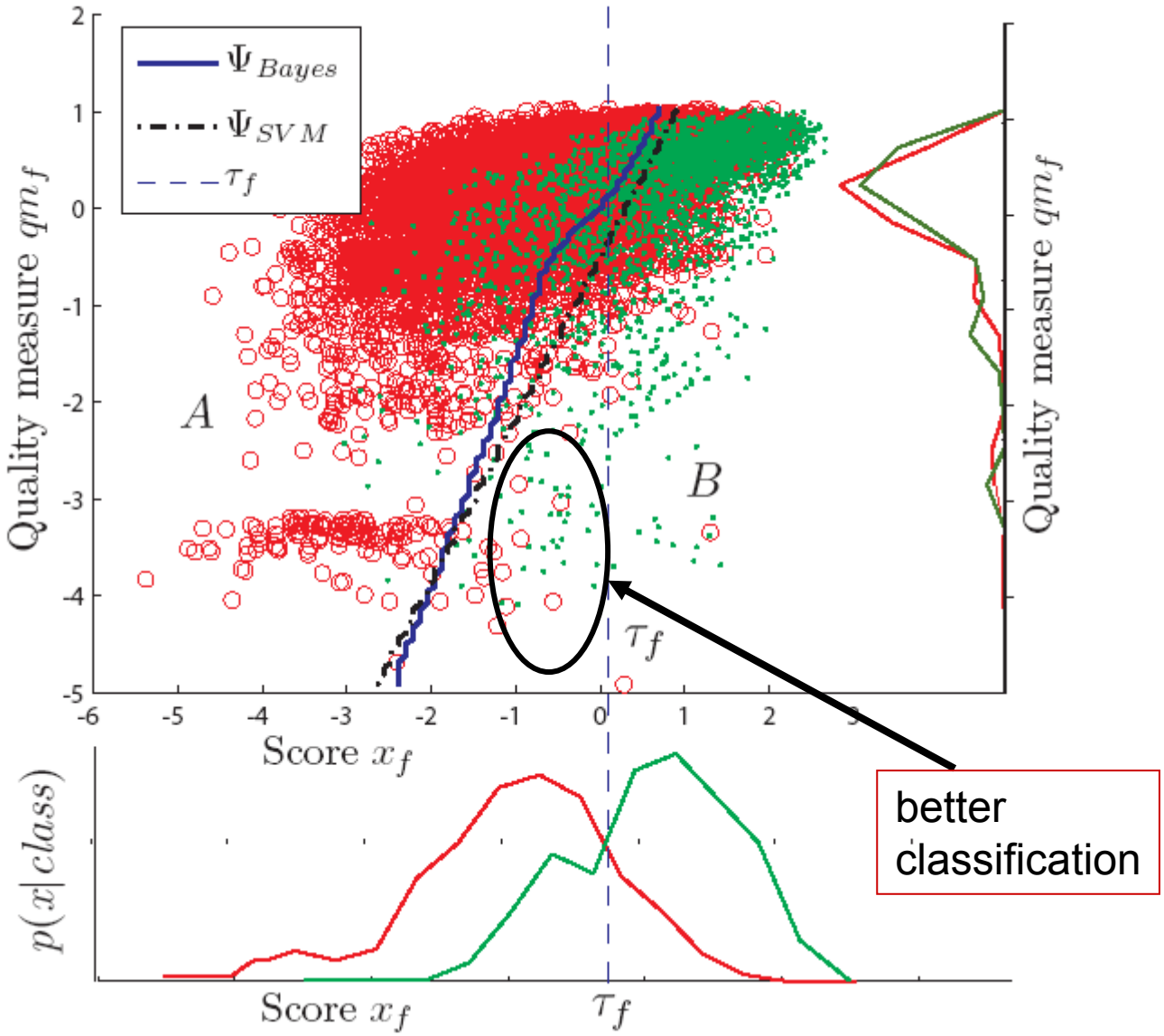


Q-stack is a general framework of stacking classification with quality measures that is applicable to uni-, multi-classifier and multimodal biometric verification with one or more quality measures.

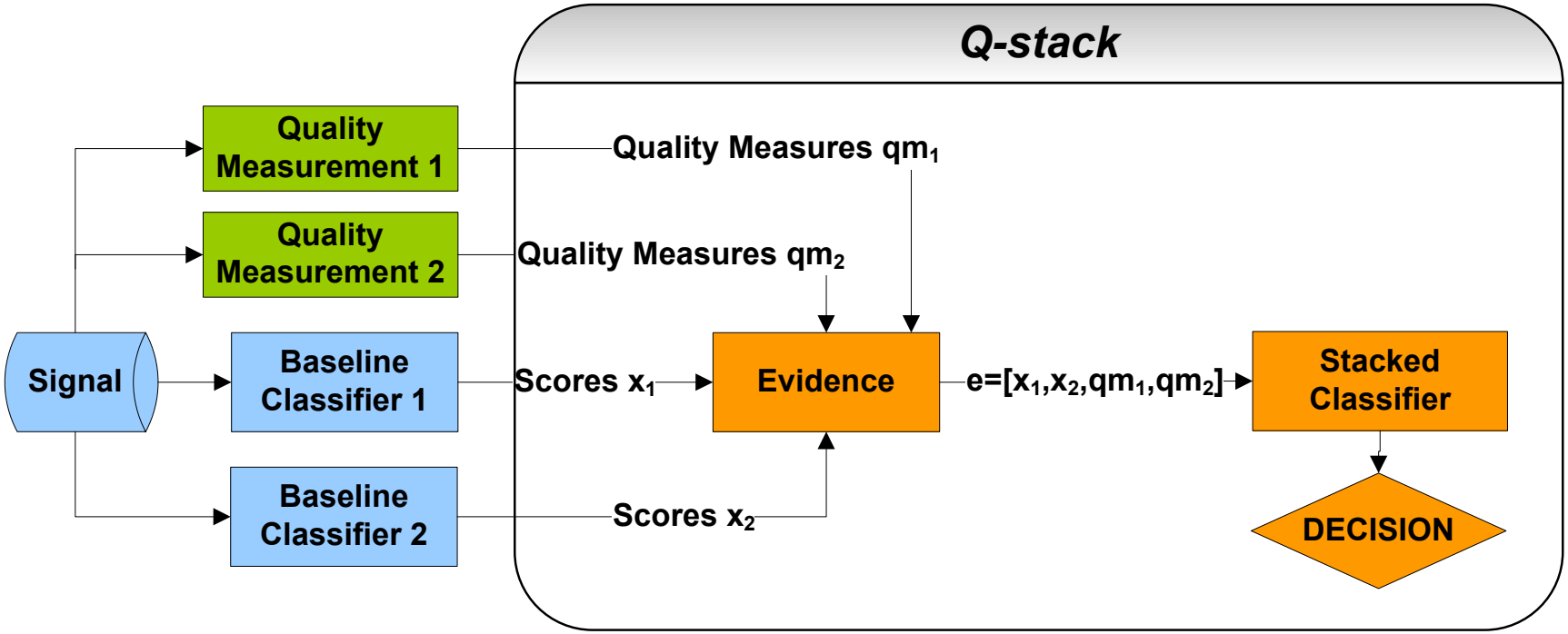


Dependence between **scores** and **quality measures** grants improved class separation

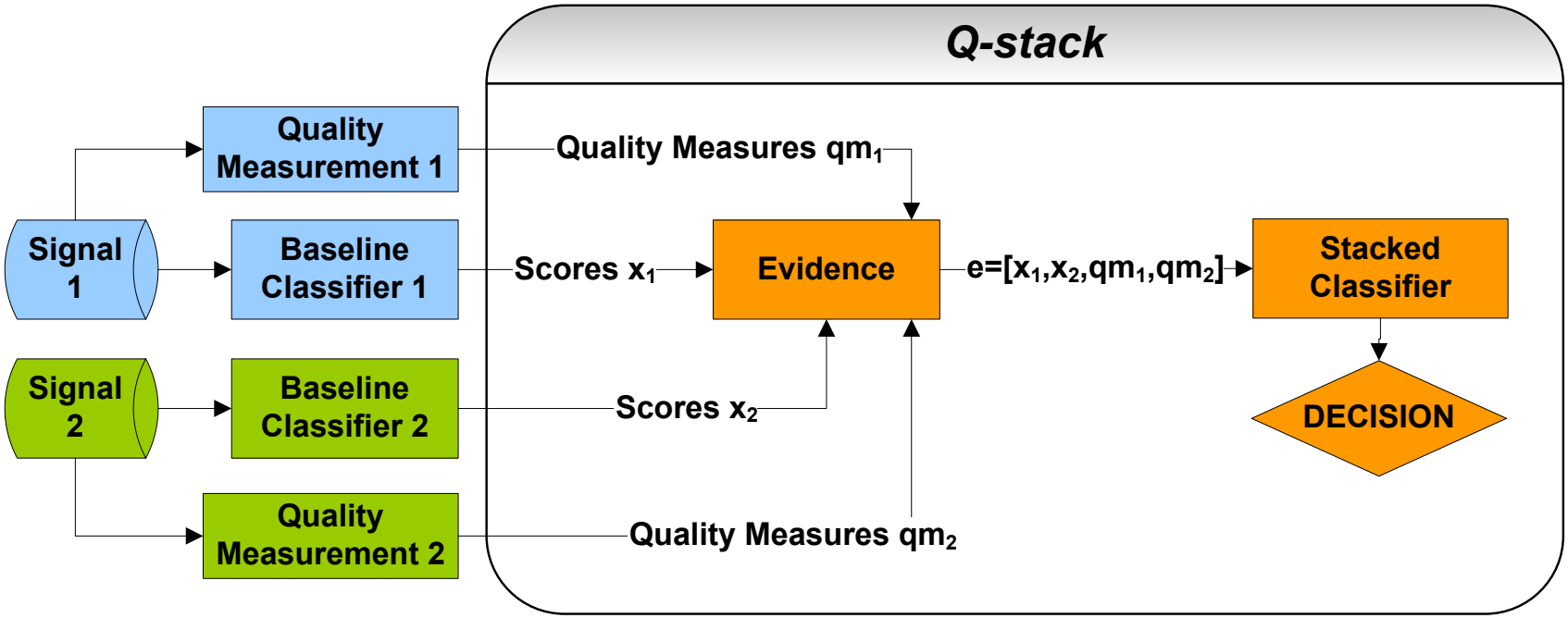
Experimental evaluation: face



Combination of quality measures and multiple classifiers



Multimodal Q-stack



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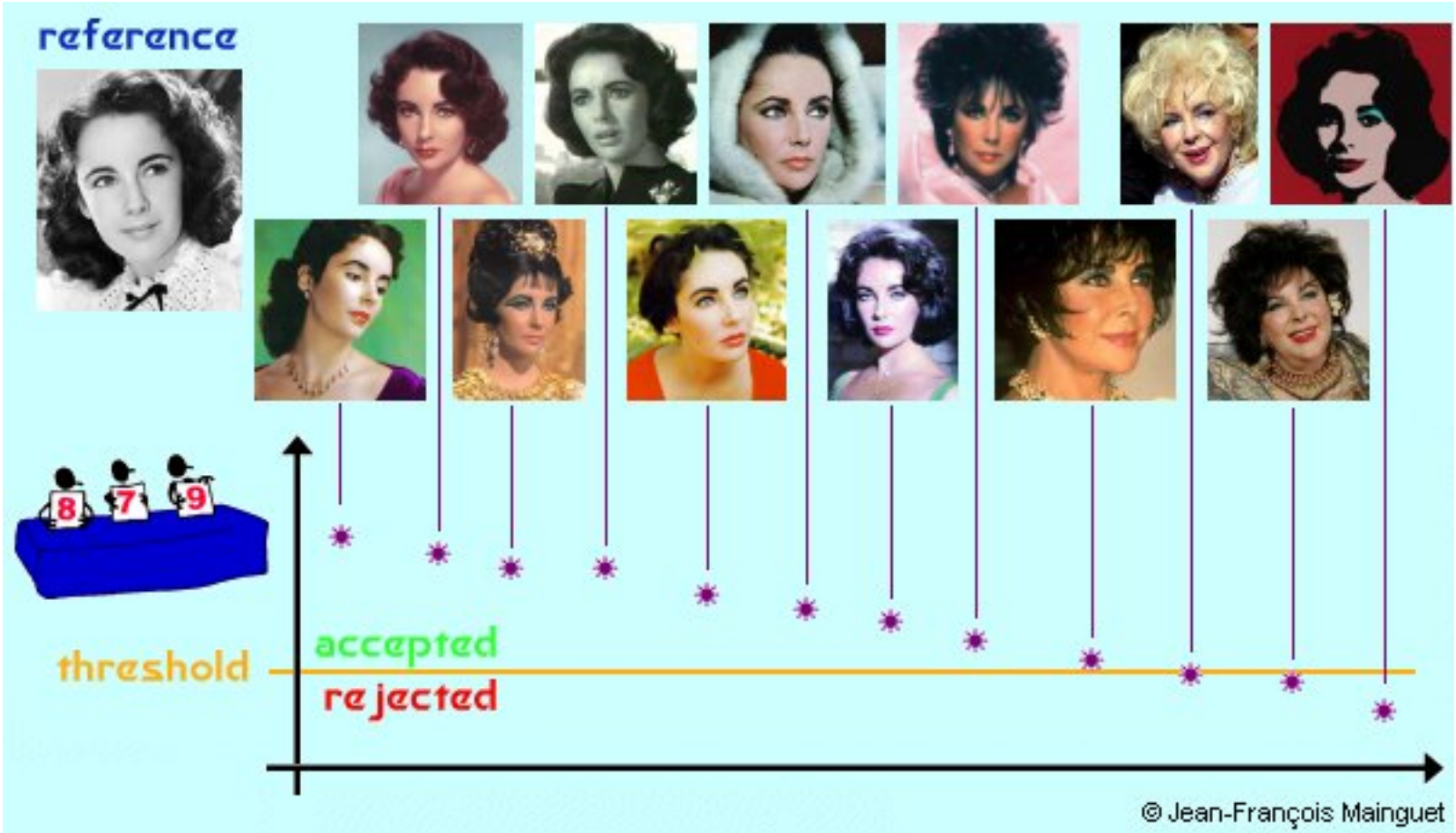
Verification of Aging Faces (Score, Age and Threshold)

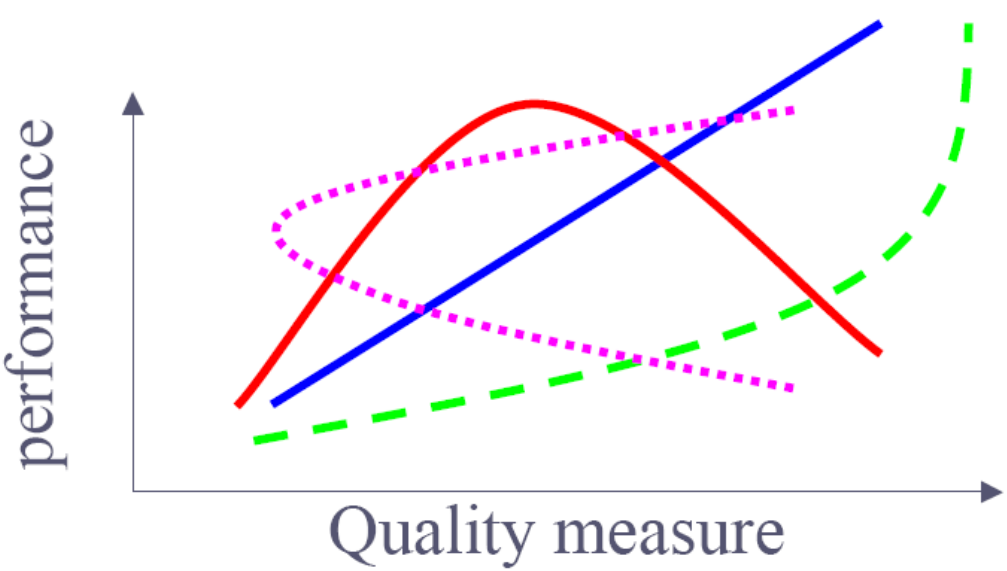


Face Aging

- Nowadays, digital face images are becoming prevalent in travel and identity documents (e.g. e-passports and national identity cards).
- Faces undergo gradual variations due to aging.
  - Aging is a complex process that affects both the shape of the face and its texture.
- Individual face models created at some point in time may become less relevant or even obsolete as the time passes.
- The problem of time validity of face biometric models has received only a marginal attention from researchers compared with pose, lighting, and expression variations.

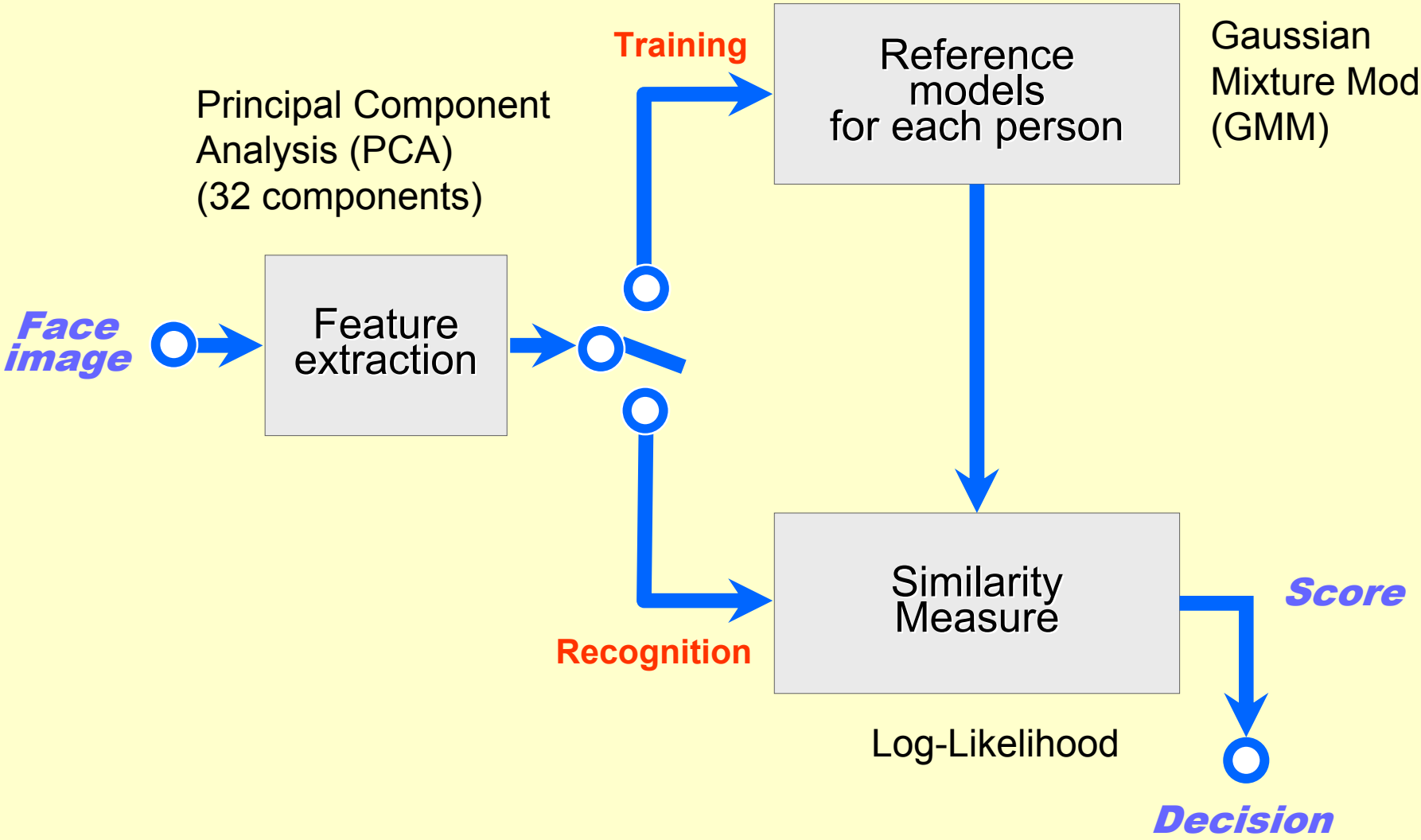
Research Goal

- To introduce a novel theoretical approach to incorporating age, based on the concept of metadata quality measure, into the face verification process, based on the concept of classifier stacking (Q-stack).



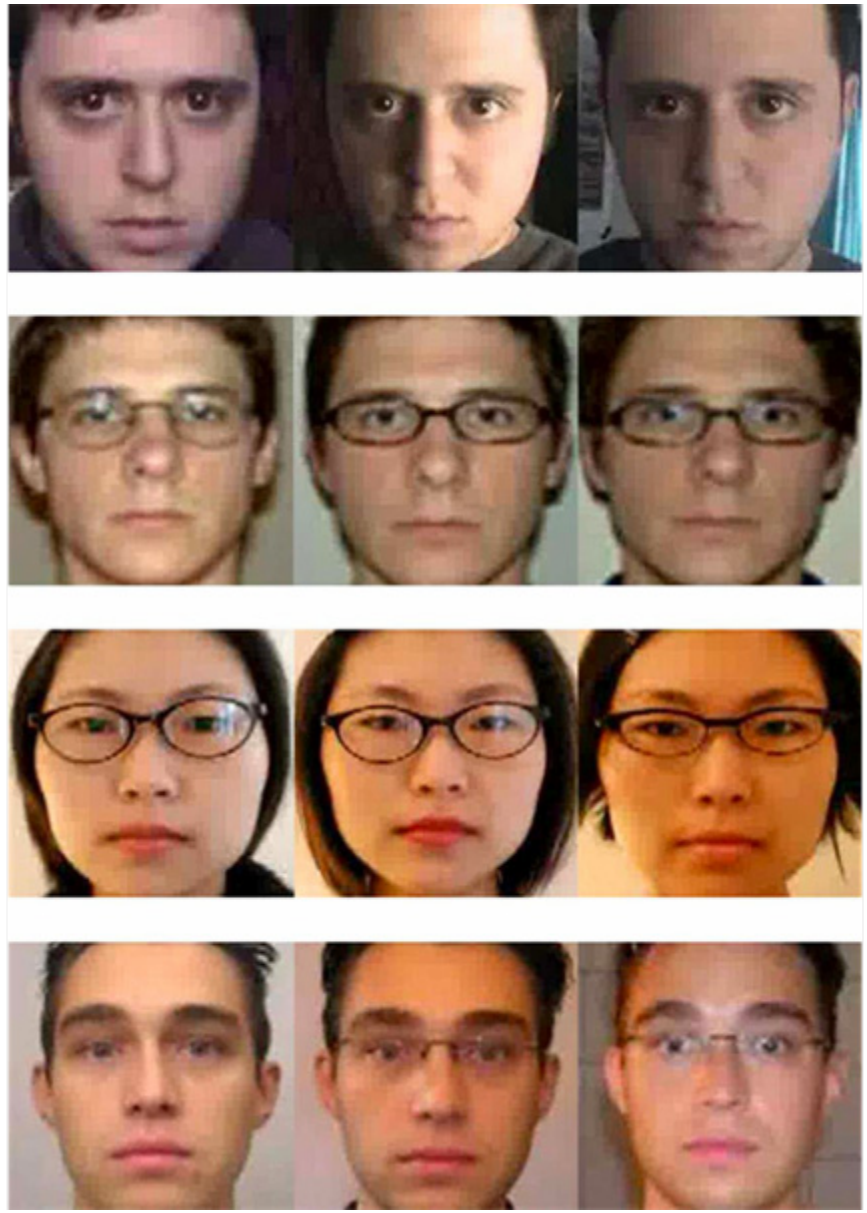
A data driven approach: If a relationship exists, a learning algorithm should be able to model it

Baseline structure of face recognition system



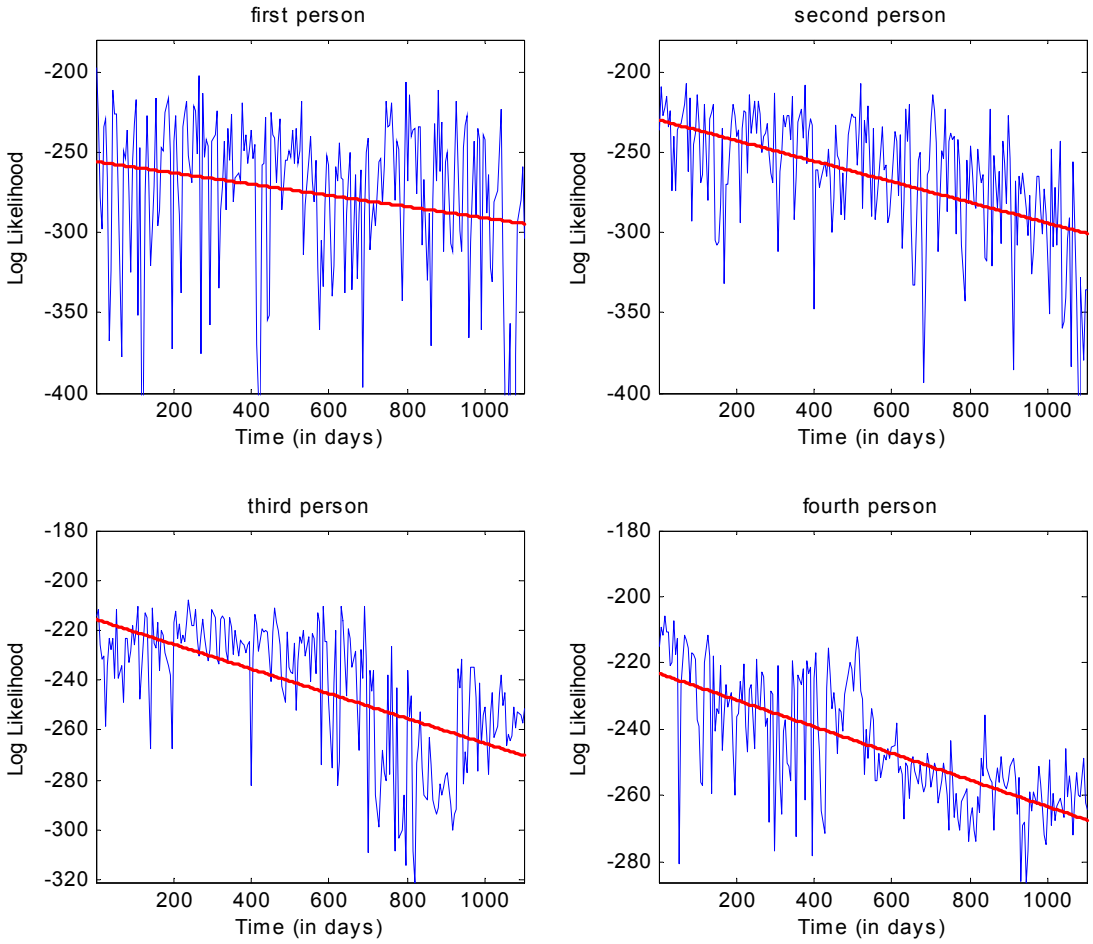
Database 1 (YouTube)

- Face images extracted from the videos "one picture a day"
- Four persons recorded during 1200 days
- Face image size: 640 × 480 pixels
- Face position: frontal (no emotion and makeup)



Database 1 (YouTube) – Video Example

Aging Influence on the Face Classifier



Linear fit

Correlation
Mutual Information

Person	first	second	third	fourth
PCC	-0.21	-0.52	-0.61	-0.69
MI	0.09	0.12	0.23	0.27

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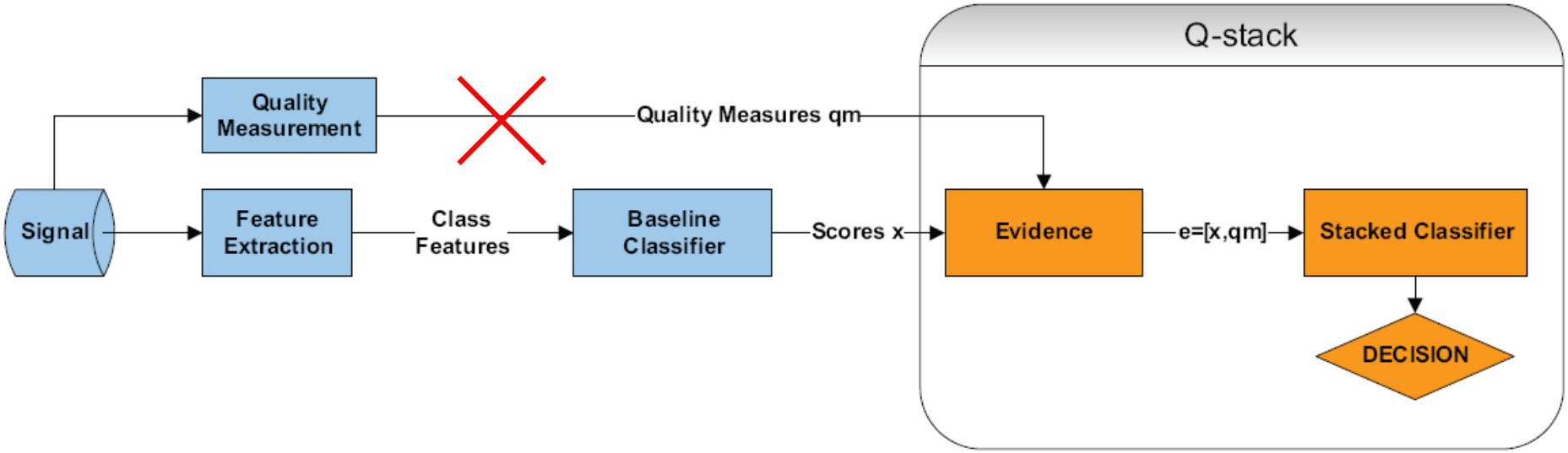
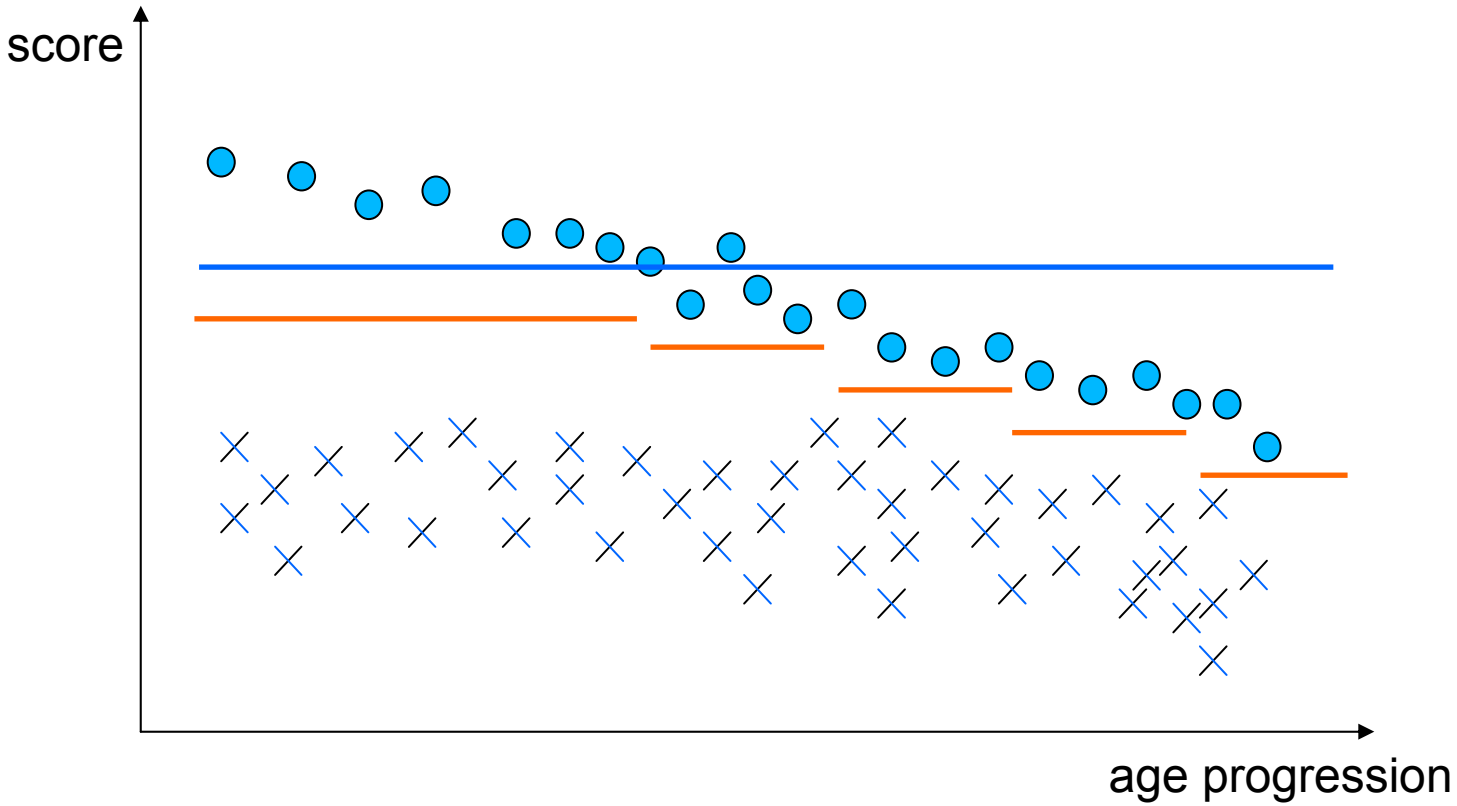
How to use age as a metadata quality measure?

Age
Metadata
Quality Measure



Age – time difference between the template (model) creation and the query image testing

How to select the threshold?



The overall system performance can be potentially improved by updating in time a decision threshold.

Deciding when and how to update the long-term decision threshold can be based on its short-term model.

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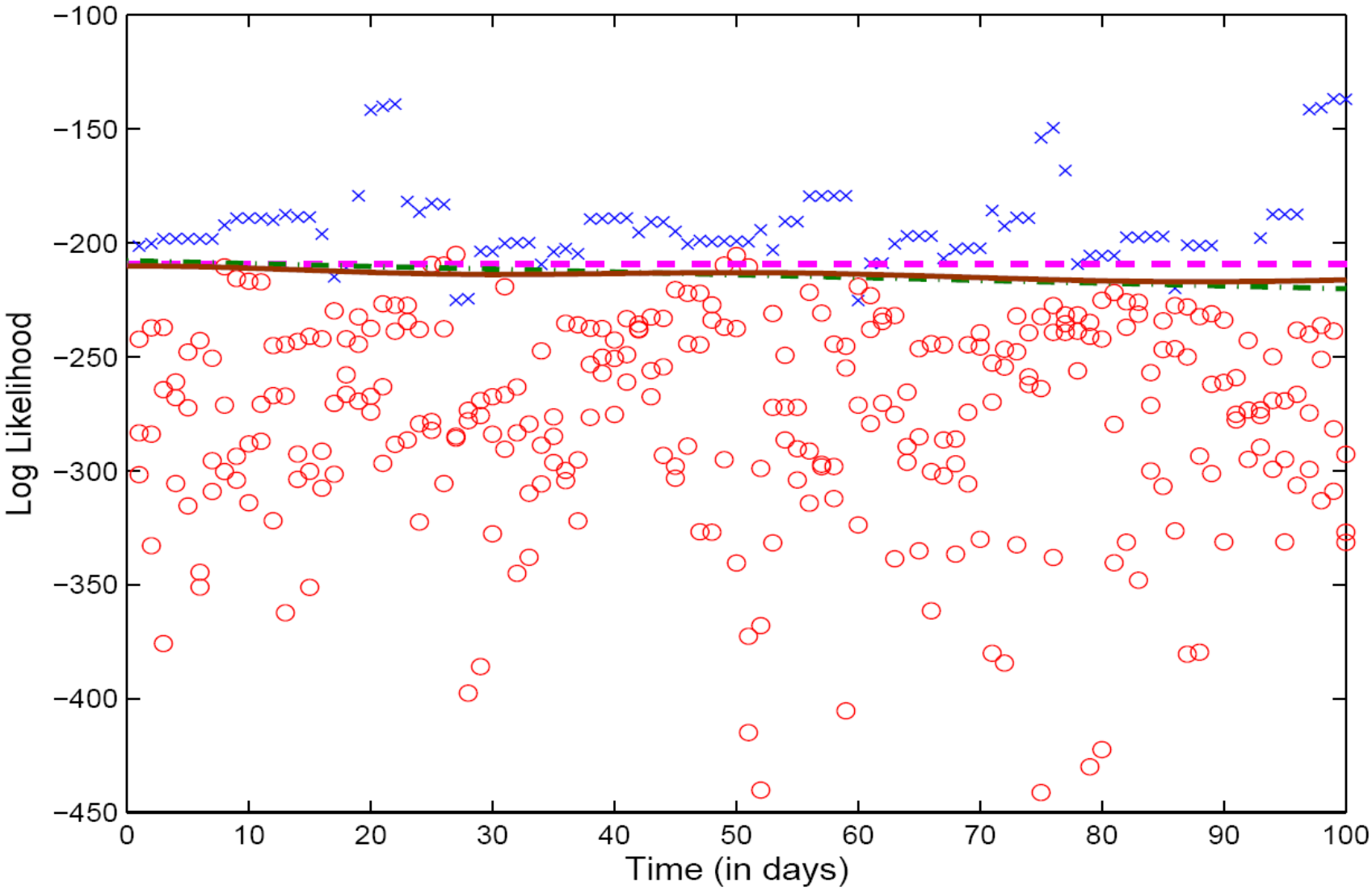
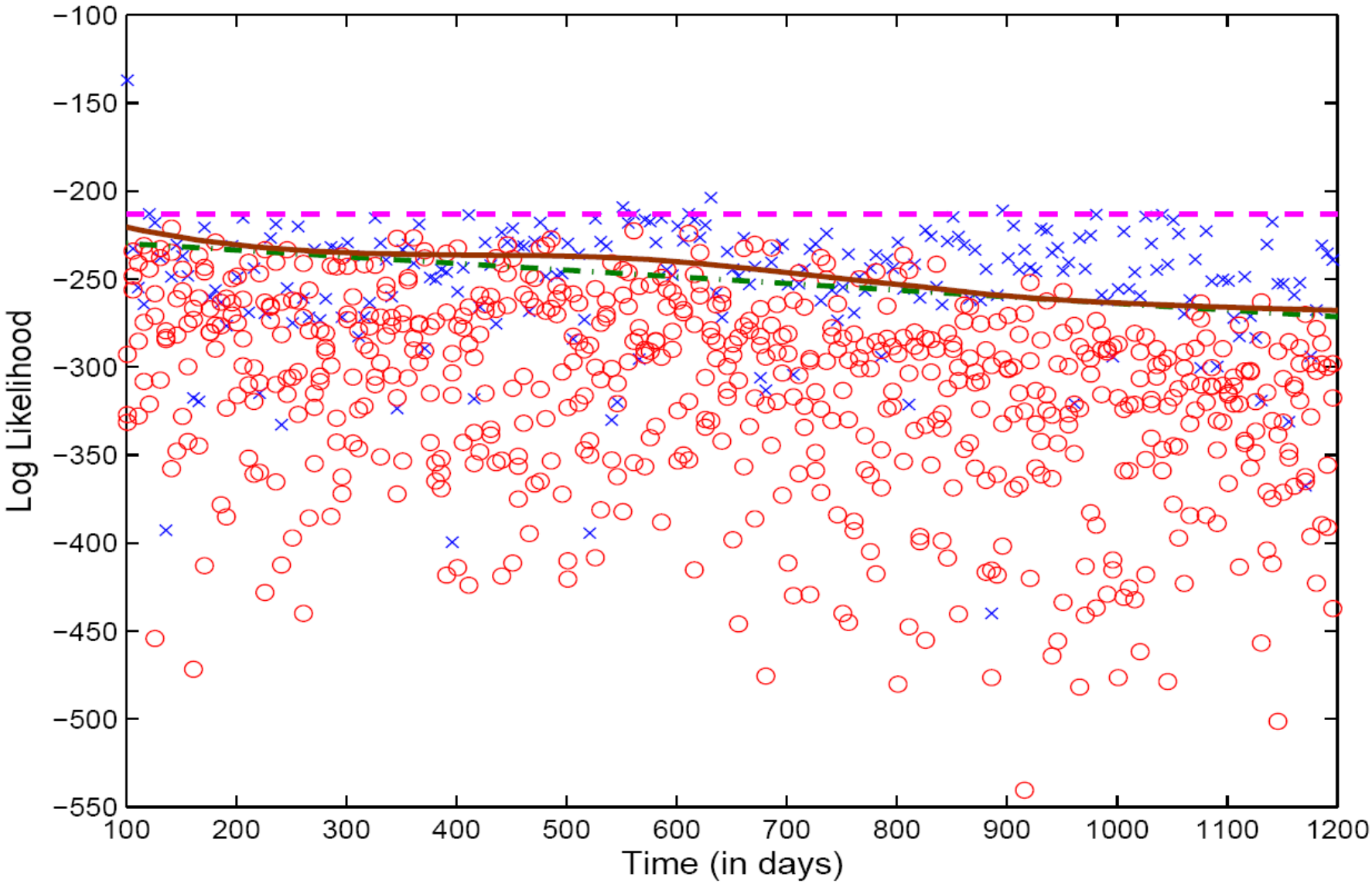
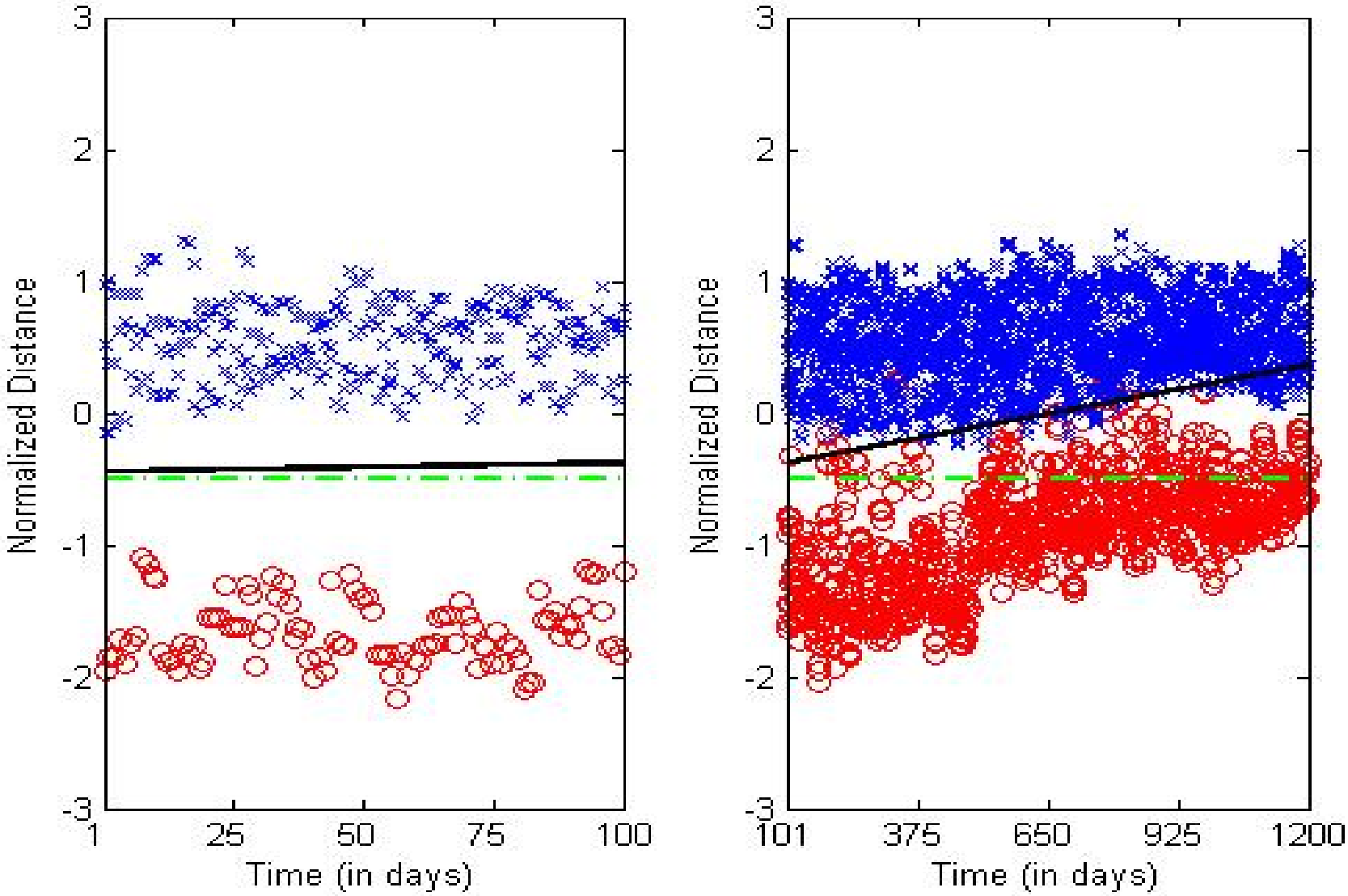
Aging Faces (Training 100 days)



Aging Faces (Testing 1100 days)



Local Ternary Patterns and Q-stack



Verification Performance

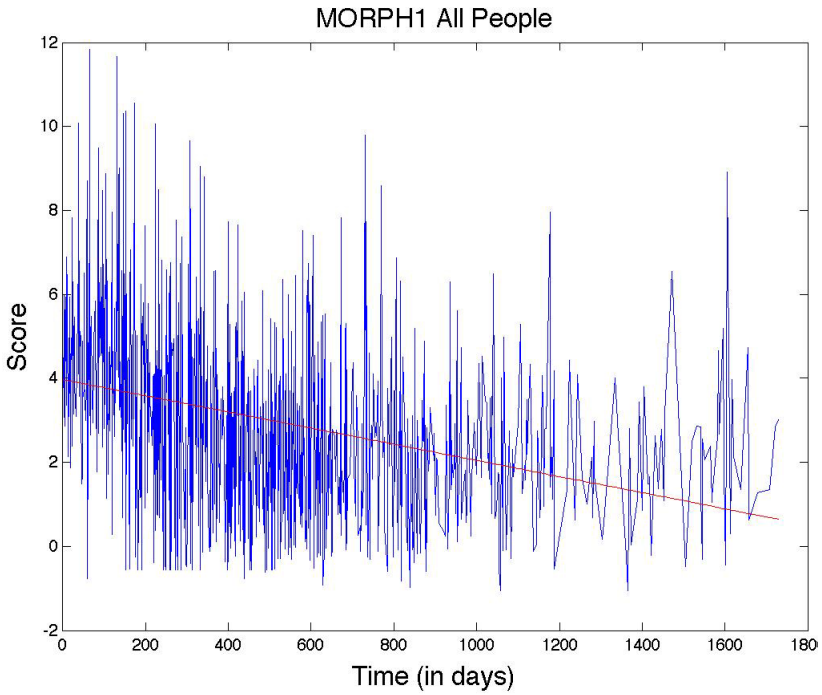
	0-0.5 year	0.5-1.0 year	1.0-1.5 years	1.5-2.0 years	2.0-2.5 years	2.5-3.0 years
Baseline						
FAR [%]	0	0	0	0	0	0
FRR [%]	6.67	5.56	11.67	24.44	23.33	23.00
HTER [%]	3.33	2.78	5.83	12.22	11.67	11.50
Q-stack method						
FAR [%]	0	1.11	2.22	3.89	1.11	15.00
FRR [%]	2.78	2.22	0	3.89	0	0
HTER [%]	1.39	1.67	1.11	3.89	0.56	7.50

Database 2 (MORPH)

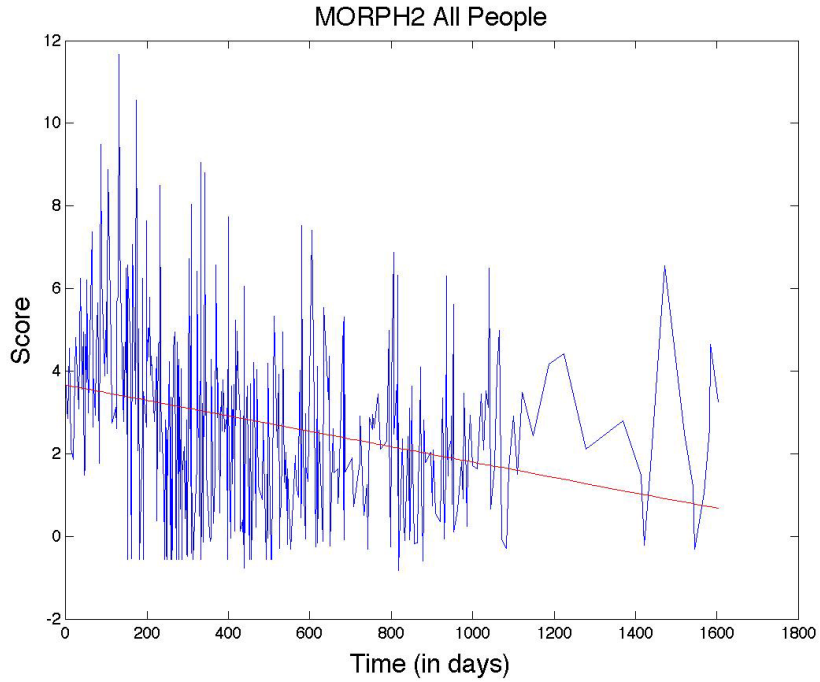
- Publicly available database used for investigation of age progression
- Contains 1,724 face images of 515 individuals
- 34 individuals whose images are more than 20 were selected
- 14 individuals with more than 20 images for each individual and without the significant head pose and facial expression variations

Aging Influence on the Face Classifier

34 individuals



14 individuals



	FAR [%]	FRR [%]	HTER [%]
Baseline	0.05	30.47	15.76
SVM-lin	0.29	10.93	5.61
SVM-rbf	0.10	6.40	3.25

Conclusions

- Data and metadata quality measures can be treated as classification features.
- Q-stack is applicable to single-, multiple-classifier and multimodal systems.
- A novel theoretical approach to incorporating age, based on the concept of metadata quality measure, into the face verification process, based on the concept of classifier stacking (Q-stack) was introduced.
- Q-stack aging model is a powerful method of combining scores and age for improved long-term classification.
- Combination of age information with different quality measures of face image and multiple baseline classifiers is possible.