Project no.:	IST-2005-027351
Project acronym:	MTIT
Project title:	Minutiae template interoperability testing
Instrument:	Specific targeted research project
Thematic Priority:	Information Society Technologies
Start date of project:	November 1, 2005
Duration:	17 months

Deliverable D 6.2:

Research report on minutiae interoperability tests

Version 1.0

Due date of deliverable:	March 31, 2007
Actual submission date:	March 31, 2007
Lead contractor for this deliverable:	NPL Management Ltd

Project co-funded by the European Commission within the Sixth Framework Programme (2002–2006)		
Dissemination Level		
PU	Public	✓
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Contents

1 Purpose of the document

This report describes the research outcomes of the MTIT project. It discusses those issues furthered by the MTIT project, those requiring feedback to SC37 for adoption into further revisions of standards [ISO/IEC 19794-2] and those identified as requiring further development to resolve.

It also discusses those areas that were not fully explored by this project and require further investigation. Full details of the results used to generate these conclusions may be found in [MTIT D5.1].

The structure of this document is as follows: we first describe those issues that directly affect the interoperability of systems, we then discuss those issues that effect interoperability testing, and finally provide a set of recommendations to SC37.

2 Issues effecting interoperability

In this section we describe our findings from the MTIT project that directly impact on the interoperability of systems. We highlight three key areas for consideration: false minutiae, minutiae placement and detection strategy, problems with the compact card format, and the use of minutiae quality.

2.1 False minutiae

Our research suggests that many algorithms generate a significant number of false minutiae. Factors in the detection of these are listed below.

2.1.1 Thick ridges

Images containing thick ridges, especially where sweat pores are visible lead to many false minutiae as illustrated in Figure 1.

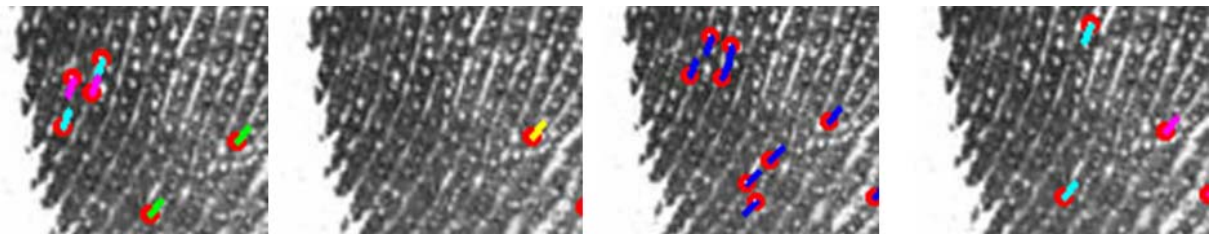

Figure 1 – False minutiae due to thick ridges and sweat pores

2.1.2 Incipient ridges

Incipient ridges are short ridges, the endings of which should not be extracted as minutiae. As can be seen in Figure 2, a number of vendors do regularly extract these artefacts.

Figure 2 - False minutiae due to incipient ridges

2.1.3 Edge effects

Some vendors repeatedly mark false minutiae on the edge of a print as is illustrated in Figure 3.

Figure 3 - False minutiae on the fingerprint edge

2.1.4 Low quality images

Images of low quality or poor character present particular challenges for minutiae extraction algorithms with a large variation in the number and placement of false minutiae. An example of this is given in Figure 4.

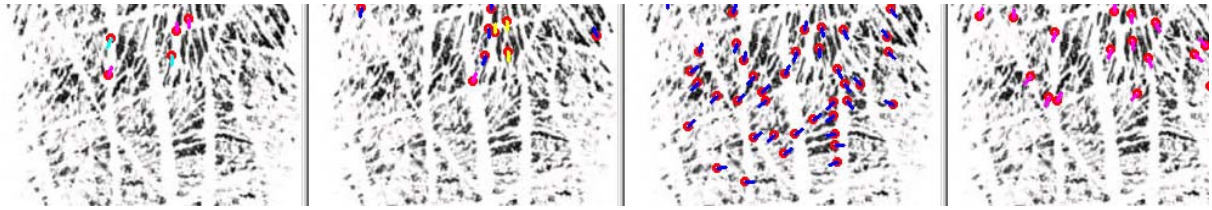

Figure 4 - False minutiae due to low quality prints

2.1.5 Minutiae below the first phalanges

No minutiae should be detected below the skin crease of the first phalanges, however some vendors will mark such minutiae as demonstrated in Figure 5.

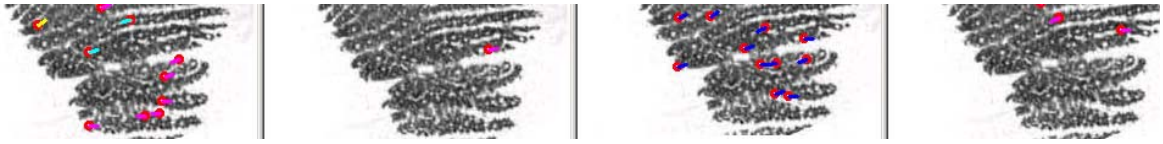

Figure 5 - False minutiae below the first phalanges

2.2 Minutiae placement

There are a number of variances within the placement of specific minutiae; examples of these phenomena are listed below.

2.2.1 High curvature

In areas of high curvature such as the core or delta, it is notably difficult to correctly place minutiae. The example in Figure 6 shows this effect.

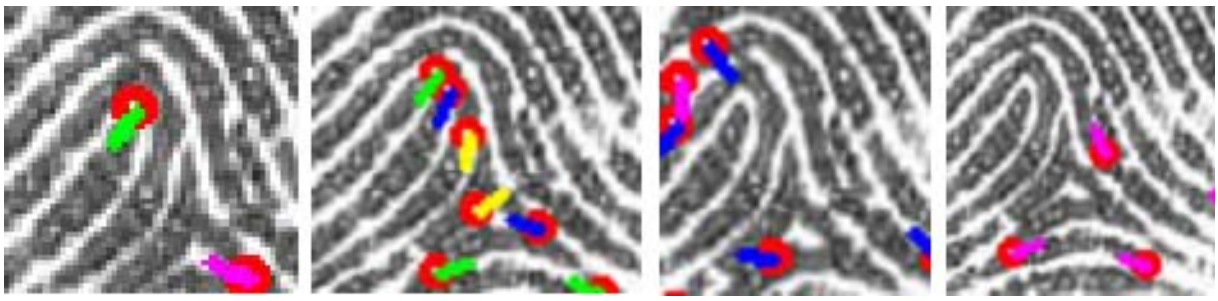

Figure 6 - Uncertain minutiae placement in high curvature

2.2.2 Short ridge variations

As illustrated by Figure 7, variations on the placement of ridge endings cause considerable differences in inter-pixel distance. This can be as much as 30% in some cases.

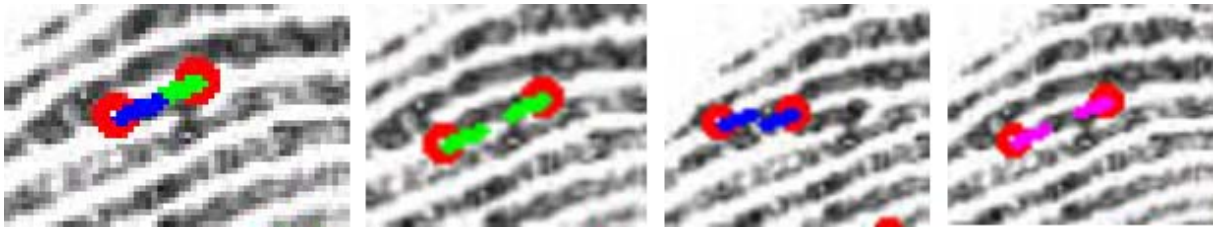

Figure 7 - Differing ridge lengths due to placement variances

2.2.3 Consistent placement differences

There are some consistent placement differences between vendors, as illustrated by Figure 8. It is apparent that vendors consistently place the same minutiae 2-5 pixels apart and rarely in the location specified by ISO19794-2. However it is not clear that this small and consistent variation has a significant effect on interoperable performance.

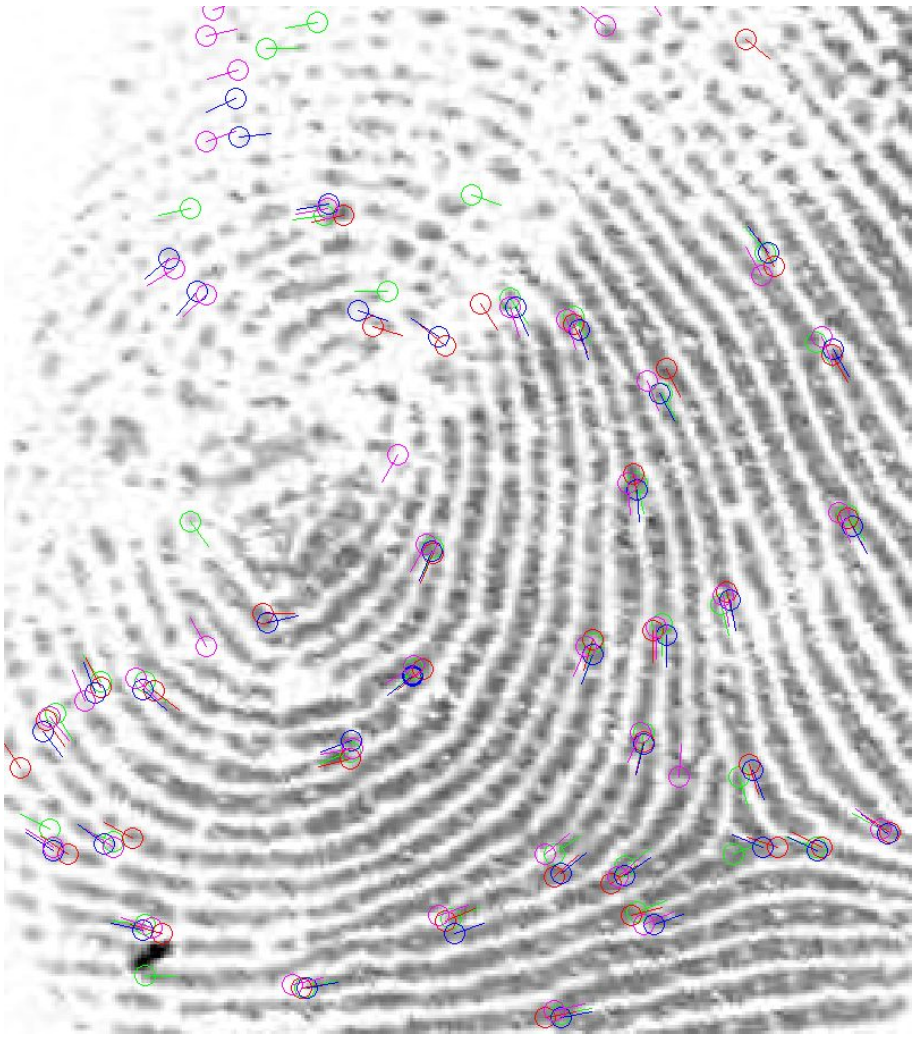

Figure 8 – Consistent variances in minutiae placements

What does have a more dramatic effect on interoperable performance is the behaviour of various suppliers' minutiae extraction algorithms. It is clear that some vendors place a large number of minutiae points, relying on minutiae quality scores to determine those to be used for matching, whereas others place very few points, all of which are of high certainty. This problem is compounded by differing policies on whether minutiae are to be placed near the core and/or near the edge of the print. It was notable from our investigation phase that the least interoperable vendors, were at either extreme of the liberal vs. conservative placement axis. An additional factor in this discussion is the reliability and use of the minutiae quality value, which is fully explored in section 2.4.

2.3 Compact card format

The key difficulty identified within the compact card format is how one should manage images that are greater than 2.55mm in either aspect. Whilst provisions are made for peeling off minutiae from the convex hull of the minutiae set (ISO/IEC 19794-2, section 8.3.1) and for coordinate extension in either X or Y (ISO/IEC 19794-2, section 8.3.4), vendors did not

feel this was sufficient especially where minutiae could exceed this limit in both directions. Within the project various methods for image cropping were discussed, however this went beyond the scope of the standard and was therefore rejected.

2.4 Minutiae quality

As discussed in section 2.1 there is a significant problem with vendors choosing to place significantly different numbers of minutiae on the same image; this is exacerbated by vendors not utilising the minutiae quality fields when performing matching. At present vendors do not appear to have confidence in the way quality scores are arrived at, nor for their suitability in informing their matching process. Because the current field is so ill specified it is difficult to verify that vendors are properly conformant to the standard even on a range of images.

Vendor preferred solutions to this problem included: modification of the header to include identification of the extraction algorithm, calibration of minutiae quality scores on a publicly available 'gold-standard' dataset, or a standardised minutiae quality assessment methodology.

3 Issues effecting interoperability testing

Many of the issues noted in section 2 are due to inherent ambiguities in the standard, however some of these are also due to a lack of conformance methodologies for evaluating the semantic content of the templates. At present our methods of conformance assessment will only indicate whether a set of templates are suitable for interoperability testing to proceed, and not whether many of the issues affecting interoperability have been addressed by the vendor.

Vendors found the two-stage process for evaluating interoperability very valuable, and it is recommended that in future tests minutiae encodings are made available to ensure a convergence of approach. This is especially important whilst weaknesses remain in the specification of the standard.

The project found that assessing interoperability by utilising a fixed performance level is only appropriate in a technology evaluation where the database is specified and baseline performance is known. In contrast relative interoperability on single finger tests is fairly consistent across all databases and operating points, both in terms of performance loss between modes and outlying vendor pairs (those with interoperable performances significantly greater than average interoperable performance). Relative interoperability on the two-finger tests is more varied; it is suspected that this may be due either to the low number of errors observed or due to confounding effects of the fusion process.

The consistency of relative interoperability across databases suggests that database selection (providing sufficient errors are present to give meaningful performance measures) is not an important factor when determining the best or worst interoperating systems.

This project has identified that the findings of the MINEX project [MINEX] are broadly applicable to ISO/IEC 19794-2 templates. We do however find that only in about half of the cases does the native case provide the most conservative threshold in our fixed threshold tests, an effect which is consistent across databases.

4 Recommendations

The MTIT project will raise the following key items for discussion at the SC37 meetings in Berlin during June 2007:

- Guidance on the strategies for minutiae extraction should be made more explicit, especially concerning placement on the edge of the finger or at the core.
- The maximum permissible image size for the compact card format should be stated and a standard method for dealing with larger images should be provided.
- Automated methods for semantic quality assessment might be developed, using either a reference implementation, or a ground truth or calibration database.
- A standard method for determining or minutiae quality should be developed along with a way of determining conformance with this process. Alternatively requiring calibration of minutiae properties (i.e. quality histogram, average number of minutiae) using certain public sets of fingerprint images.
- Methods for using relative interoperability as a robust, database independent measure for defining a set of interoperable systems.

References

[ISO/IEC 19794-2] International Standard ISO/IEC 19794-2:2005, Information technology – Biometric data interchange formats – Part 2: Finger minutiae data

[MTIT D5.1] Interoperability testing report, Deliverable D5.1 of the MTIT Project

[MINEX] Performance and Interoperability of the INCITS 378 Fingerprint Template. NIST, NIST Interagency Report NISTIR 7296, March 2006, http://fingerprint.nist.gov/minex04/minex_report.pdf