

Concealed Bomb Detection by Automatic Gait Recognition

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Abstract— Terrorist attacks on the Western world have prompted increased discussion and research into the range and application of biometric technologies. Gait has been identified as a useful tool for non-intrusive identification of subjects at a distance where other biometrics may fail. This paper presents background on the use of gait as a biometric and methods for its capture and analysis. Clinical evidence for the effect of load carriage on gait patterns is explored and studies assessing the gait of obese persons provide significant evidence in support of load carriage detection. Preliminary experiments to detect concealed loads carried under clothing are outlined. The Southampton biometric tunnel was used and the three dimensional reconstructed data analysed to extract gait metrics. Early stage analysis is encouraging.

1. Motive

- Recent terrorist attacks have raised the profile and use of biometrics. Current biometrics are intrusive and are not effective at distance.
- Gait can be used at distance, without the subject even knowing. This has applications in security conscious environments such as airports and stations.
- Bombs are now often concealed beneath clothing where previously they were commonly carried in backpacks which were more detectable[1].
- Some limited research already explores changes in gait during load carriage, however there is a lack of research into changes when items are concealed beneath clothing.



Fig. 1. Research has been performed that detects prominent load carriage from silhouettes. [2]

- A detection method would also have parallel commercial uses, e.g. automatic warning of shoplifting.



Fig. 2. Detection of concealed items could also be used to combat shoplifting.

2. Clinical Evidence

- Two main areas of investigation exist; the clinical and ergonomic communities, and those exploring object tracking and gait recognition (computer vision).
- Studies into backpacking subjects suggest that stride length decreases, double support time increases and single support time decreases when carrying a load. Cadence may increase to maintain walking speed. Numerous changes in kinematic parameters were also found. However, not all findings were statistically significant below load carriage of 20% of body weight.
- Obesity studies found similar changes in gait but more statistically significant.

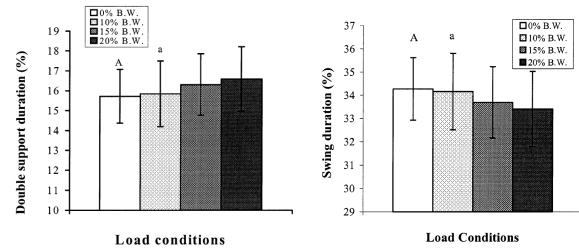


Fig. 3. While external load bearing studies identified useful trends, findings were not always statistically significant. [3]

3. Pilot Experiments

- Two experiments were performed. One required subjects to wear a "bomb harness". This consisted of eight 0.5l bottles filled with water, four on the back and four on the front. Most of the weight was carried by the shoulders. The second experiment strapped a 1.1kg weight to an ankle to simulate either concealed explosives or a weapon around the ankle.
- The Southampton Biometric tunnel was used to obtain 3D reconstructions of a subject's gait cycle.

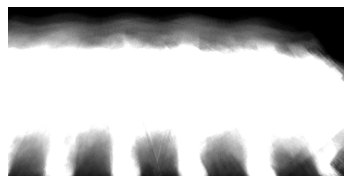
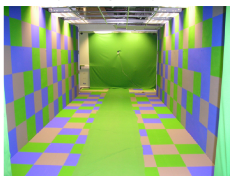


Fig. 4a. The Southampton biometric tunnel. 4b. Accumulation of silhouettes reveals periodicity.

- The "bomb harness" experiment found average silhouettes to be classified correct 70% of the time. Results from ankle experiment unavailable at time of writing.
- Silhouettes are accumulated in space to find periodicity. Extraction of stride length, walking speed and an estimate of stance phase was performed and findings were in line with clinical evidence.

4. Conclusions

- This work has reviewed gait as a biometric and methods for classification.
- Clinical evidence for changes in gait patterns under load carriage have been identified.
- Early pilot experimentation suggests that concealed load carriage is detectable. Classification by average silhouette has achieved 70% accuracy. Extraction of gait parameters has also produced encouraging results in line with clinical findings.
- The biometric tunnel would benefit from cameras at floor level to better define the 3D reconstruction in the feet region.
- Further work is required to perform full analysis of the results of the ankle bomb experiment where observers were able to see an immediate noticeable difference in gait.
- Investigation of alternative silhouette classification techniques may additionally achieve improved correct classification of gait signatures to provide a reliable suspicion rating for a security conscious system.

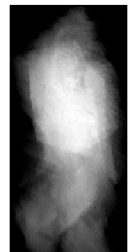


Fig. 5. Feet were poorly defined, but results were encouraging.

References

- [1] B. Hoffman, The Logic of Suicide Terrorism. The Atlantic Monthly, 2003 (June).
- [2] I. Haritaoglu, "Backpack: Detection of people carrying objects using silhouettes," Computer Vision and Image Understanding, vol. 81, pp. 385–397, 2001.
- [3] Y. Hong and G. Bruggemann, "Changes in gait patterns in 10-year-old boys with increasing loads when walking on a treadmill," Gait and Posture, vol. 11, pp. 254–259, 2000.