UNIVERSITI PUTRA MALAYSIA

3D FACE REGISTRATION ACROSS POSE VARIATION AND FACIAL EXPRESSION USING CROSS PROFILE ALIGNMENT

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3D FACE REGISTRATION ACROSS POSE VARIATION AND FACIAL EXPRESSION USING CROSS PROFILE ALIGNMENT

By

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3D FACE REGISTRATION ACROSS POSE VARIATION AND FACIAL EXPRESSION USING CROSS PROFILE ALIGNMENT

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June 2011

Chair : Syamsiah binti Mashohor, PhD

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In a 3D face recognition system, face registration is usually employed to compensate the pose variation in a 3D face model. Most previous methods in 3D face registration are based on the well known global-based approach, Iterative Closest Point (ICP). The experiments are usually conducted using cleaned and frontal-viewed face models, neglecting the facial variation that often occur in real-time scenarios, such as pose variation, facial expression, facial outliers and occlusion. The proposed thesis uses a local-based approach known as Cross Profile Alignment (CPA) as an alternative to the global-based approach, utilizing the facial feature of a face surface as an attempt to cater all the above problems.

Among all features on a face surface, nose tip is the most commonly used feature for facial feature landmarking. It is crucial to accurately detect the nose tip as it will affect the overall performance of the registration process. Most of the presented nose tip detection algorithms were developed merely based on the assumption that the nose tip is the highest point on a face, which is not robust enough for face model

under large rotation variation and having large facial outliers. Thus, as the first step prior face registration, the thesis proposed a novel nose tip region detection algorithm using localized point signature, developed specially to locate the nose tip region across various facial variation.

The experiment conducted on challenging 3D face databases yields good results with 94.77% detection rate for the nose tip region detection algorithm. Based on the nose tip region location, a cross-profile is extracted and face model is compensated for rotation variation and translation displacement. The registration framework with CPA which gained accuracy rate of 93.9% when tested within 10 degrees error margin, outperforms the registration framework with ICP using Average Face Model (AFM) with accuracy rate of 87.7%, with lower processing time. The findings during this work indicate the accuracy and the reliability of the proposed registration framework towards 3D face model with challenging facial variation.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENDAFTARAN WAJAH 3D MERENTASI VARIASI GAYA DAN EKSPRESI WAJAH MENGGUNAKAN PENJAJARAN PROFIL BERSILANG

Oleh

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Di dalam sistem pengecaman wajah 3D, pendaftaran wajah lazimnya dilaksanakan untuk mengatasi masalah variasi gaya pada model wajah 3D. Kebanyakan kaedah pendaftaran wajah 3D yang terdahulu adalah berdasarkan kepada kaedah berasaskan global yang diketahui umum, *Iterative Closest Point (ICP)*. Eksperimen yang telah dilaksanakan lazimnya menggunakan model wajah yang telah dibersihkan dan menghadap posisi hadapan, tanpa mengambil kira variasi wajah yang selalu wujud dalam persekitaran realiti-masa seperti variasi gaya, ekspresi wajah, lebihan dan penambahan pada wajah. Tesis ini mencadangkan penggunakan kaedah berasaskan tempatan yang dikenali sebagai Penjajaran Profil Bersilang (CPA) sebagai alternatif kepada kaedah berasaskan sejagat, dengan menggunakan ciri-ciri pada permukaan wajah sebagai percubaan untuk mengatasi semua masalah di atas.

Di antara semua ciri-ciri yang terdapat pada permukaan wajah, puncak hidung didapati paling banyak digunakan untuk tujuan penandaan wajah. Adalah sangat

penting untuk mengesan puncak hidung dengan tepat kerana ia akan mempengaruhi prestasi proses pendaftaran secara keseluruhannya. Kebanyakan algoritma pengesanan puncak hidung yang telah dikemukakan sebelum ini adalah semata-mata berdasarkan anggapan bahawa puncak hidung merupakan titik paling tinggi pada wajah, di mana kurang tepat bagi model wajah yang mempunyai putaran yang besar dan unsur asing yang banyak. Oleh sebab itu, sebagai langkah pertama sebelum pendaftaran, tesis ini mencadangkan algoritma baru pengesanan bahagian puncak hidung dengan menggunakan *point signature* yang telah diubahsuai, dibangunkan khas untuk mengesan bahagian puncak hidung dalam pelbagai variasi wajah.

Eksperimen yang telah dijalankan ke atas pangkalan data wajah 3D yang mencabar telah menghasilkan keputusan yang baik dengan kadar pengesanan 94.77% untuk algoritma pengesanan bahagian puncak hidung. Berdasarkan lokasi puncak hidung ini, profil bersilang boleh diekstrak dan model wajah dibetulkan dari segi putaran dan sesaran peralihan. Rangka kerja pendaftaran menggunakan CPA memperolehi kadar ketepatan 93.9% apabila diuji dengan jidar ralat 10 darjah, mengatasi rangka kerja pendaftaran menggunakan ICP dengan *Average Face Model (AFM)* dengan kadar ketepatan 87.7%, dalam masa pemprosesan yang lebih rendah. Penemuan-penemuan sepanjang kerja ini menunjukkan ketepatan dan keboleh percayaan rangka kerja pendaftaran yang dicadangkan ke atas model wajah 3D yang mengandungi variasi wajah yang mencabar.

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I certify that a Thesis Examination Committee has met on **6th June 2011** to conduct the final examination of **Laili Hayati binti Anuar** on her thesis entitled "**3D Face Registration Across Pose Variation and Facial Expression using Cross Profile Alignment**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the **Master of Science**.

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DECLARATION

I declare that the thesis is my original work except for equations and citations which has been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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