The Application of Thermal Image Analysis to Diabetic Foot Diagnosis

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Received 3 May 2002; Accepted 12 June 2002

Abstract

Due to the deficiency of peripheral sensory and autonomic nerves and the complication of peripheral vascular disease, the patients with diabetes are prone to induce the ulcers on their limbs. If the ulcer formation or poor circulation area can be detected as early as possible, the occurrence of amputation morbidity may be reduced. In this study, the thermal image analysis is applied to characterize the superficial circulation of foot. Nine subjects with or without diabetes needing skin graft are recruited and divided into control group and experimental group. Both static and dynamic thermal images are acquired for analysis. The temperature difference percentage, Karhunen-Loéve transform, and thermal recovery tendency analysis are employed for thermal image analysis. From the results, it is shown that the area of poor circulation around the wound in the patients with diabetes may be significantly revealed using Karhunen-Loéve transform and thermal recovery tendency analysis. The thermal recovery tendency analysis needs shorter computation time and is a good parameter to early detect the ulcer formation.

Keywords: Thermal image, Diabetic foot, Skin graft

Introduction

Human has a good homeostatic control system for body conditions, including temperature, pH, etc. The temperature is a useful parameter for revealing the body healthy condition. Normally, the core temperature in our body is maintained at the 36.8 ±0.6 degree of centigrade. In the extremity of body, temperature is especially a good indicator to reflect its condition. If the temperature within some area becomes higher or lower than other areas unnaturally, then it will be considered to have some problem such as infection, necrosis, etc. Generally, the core body temperature can be easily measured by using mercury thermometer or electronic thermometry. But in the extremity, the temperature distribution is widely varied and hardly measured using traditional thermometry.

Infrared thermal image has been applied in many fields, such as military, industry, and medical field. Recently, the infrared thermal imaging technique is reapplied to breast cancer detection, peripheral arterial disease diagnosis, osteoarthritis diagnosis, and pain evaluation [1-4]. Infrared thermal imaging was employed for detection of chronic neuro-muscular injury that may not be seen in CT or MRI image [5]. For patients with diabetes mellitus, the frequently occurred complication is lower extremity amputation. It is due to foot ulceration that results in osteomyelitis, sepsis and peripheral tissue necrosis. The ulceration almost begins with poor circulation area. Therefor, foot screening regularly is very important for patients with diabetes. If the poor circulation area may be detected as early as possible, the morbidity of lower extremity amputation may then be reduced [6-9].

In 1993, Chen developed the relationship between blood flow and surface temperature [10]. Based on one-dimension simplification of the heat transfer from arteriole to dermis, dermis to epidermis, and epidermis to the surroundings, a linear relationship between blood flow and surface temperature for the skin may be obtained and demonstrated with a physical model. Later, Wu [11] applied the thermal imaging technique to screen the small vascular disease. From the fractal dimension of static thermal images, it is possible to differentiate the patients with diabetes from normal patients. In 1998, Mabuchi et al. proposed that thermal distribution of the human body based on the dermatome distribution should be symmetry [12]. For the joint arthritis patient, it is a good parameter for diagnosis. However, it is not suitable for the patients with diabetes, because all the vessels in body may be affected and hardly be differentiated between normal side and

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