Grammatical Retina Description with Enhanced Methods

Róbert Ványi¹, Gabriella Kóka², Zoltán Tóth¹ and Tünde Pető³

¹ Institute of Informatics, József Attila University
Árpád tér 2, H-6720 Szeged, Hungary
e-mail: h531774|h531714@stud.u-szeged.hu

² Department of Computer Science, Programming Languages
Friedrich-Alexander University of Erlangen-Nürnberg
Martensstr. 3, D-91058 Erlangen, Germany
e-mail: kokai@informatik.uni-erlangen.de

³ Department of Ophthalmology
Albert Szent-Györgyi Medical University
Korányi f. 12, H-6720 Szeged, Hungary
e-mail: peto@oph.szote.u-szeged.hu

Abstract. In this paper the enhanced version of the GREDEA system is presented. The main idea behind the system is that with the help of evolutionary algorithms a grammatical description of the blood circulation of the human retina can be inferred. The system uses parametric Ládendmayer systems as description language. It can be applied on patients with diabetes who need to be monitored over long periods of time. Since the first version some improvements were made, e.g. new fitness function and new genetic operators. In this paper these changes are described.¹

1 Introduction

In this paper the enhanced version of the GREDEA (Grammatical Retina Description with Evolutionary Algorithms [5]) system is presented. This system is being developed to describe retina images. The main idea behind this system is to work out patient-specific monitoring programs for examining the blood circulation of the human retina. The system can be used on patients with diabetes who need to be monitored over long periods. It is essential to check the eyesight of patients with this disease, because the deterioration of the vascular tree caused by diabetes has a direct effect on the vision quality.

The first version GREDEA system had some restrictions: Only simple images were allowed and the convergence speed was low. The solutions of these problems are discussed in the following sections.

We proceed as follows. In Section 2 the description of the GREDEA system is given. Remember that the system is still under development. Here only some

¹ This work was supported by the grants of Bayerischer-Habilitationsförderpreis 1999
approvals are described. First in Section 3 the new image processing algorithms are summarized. In Section 4 the modified genetic operators, in Section 5 the new fitness functions are presented. In Section 6 the test results are discussed. Finally in Section 7 the conclusions and some future plans are mentioned.

2 The GREDEA system

The GREDEA system (see in Figure 1) is designed to describe the blood vessels of the human retina using some kind of grammars. The first version of the system is described in this section. In GREDEA an individual description of the blood circulation of the human retina is created for each patient. To obtain the description, the process starts from preprocessed fundus images taken with a fundus camera. It is assumed that the background is black (0 values) and the vascular tree is white (1 values). Later these images are referred to as destination images.

Then a parametric Lindenmayer system (L-system) – creating the pattern closest to the vascular tree of the patient – is developed. This L-system can be stored (this storage method needs less storage than bitmap images) and used later to make comparisons. If the patient returns for a check-up, new pictures are recognised and preprocessed, but the previously generated L-system is used for starting the evolution process.

![Diagram of the GREDEA system](image)

**Fig. 1.** Structure of the GREDEA system

L-systems are parallel grammatical rewriting systems. With the help of them complex objects can be described by starting from the axiom and using the productions [13]. When choosing the representation form, the fact that L-systems can be evolved using evolutionary algorithms [6] was taken into consideration.

Since parametric L-systems are evolved, two kinds of evolutionary algorithms are applied: genetic programming [3] is used on the rewriting rules of the evolved L-systems, and evolution strategies [12] are applied on the parameters of these L-systems.