Nephron Algorithm Optimization: 
Inspired of the Biologic Nephron Performance

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ABSTRACT

A new Meta heuristic algorithm inspired of the biologic nephron performance for optimization of objective functions in Np-hard problems is introduced. The complexity of the problems increases with their size, and hence their solution space increases exponentially. Despite of designing the several search techniques with balanced exploration and exploitation in order to solve such as these problems, there are some drawbacks to make suitable adjustment between exploring and exploiting in performance of the Meta heuristic algorithms. The proposed algorithm in this paper can adjust between intensification and diversification strategies intrinsically, to make efficient optimization technique. For testing Nephron algorithm optimization (NAO), the traveling salesmen problem (TSP) is provided as a solution in various sizes. Results indicate that NAO provides robust optimal solutions.

KEYWORDS

Diversification, Intensification, Meta Heuristic, Nephron Algorithm Optimization

1. INTRODUCTION

In this paper, we introduce a new approach to optimize objective function of Np-hard problems. This algorithm was discovered through studying biological nephron performance. So we could simulate new algorithm, which search optimized solutions according to the functions of the nephron. In mathematical optimization and computer science, a meta-heuristic is defined a higher-level procedure or heuristic (partial search algorithm) that may provide a sufficiently good solution for an optimization problem, however, with incomplete information or limited computation capacity (Bianchi et al, 2009). Several books and survey papers have been published on the subject of meta-heuristic (Bianchi et al, 2009; Blum and Roli, 2003; Glover and Kochenberger, 2003; Goldberg, 1989). In nature-inspired meta-heuristic algorithms, there are two key components including local intensification and global diversification. Their interaction can significantly affect the efficiency of a meta-heuristic algorithm (Yang et al, 2013). In this research, the new version of primary algorithm (Behmanesh and Rokni, 2014) is introduced. Besides, the algorithm is illustrated and tested by providing valid examples of NP-hard problems.

1.1. Nephronology

A nephron (derived from Greek νεφρός (nephros) meaning “kidney”) is defined as the fundamental structural and functional unit of the kidney. Its principal function is to regulate water and soluble substances by filtering the blood, reabsorbing what is needed and excreting the rest as urine. Nephrons eliminate wastes from the body, regulate blood volume and pressure (Anthea et al, 1993). Each nephron is composed of an initial filtering component (the “renal corpuscle”) and a tubule for reabsorption and
secretion (the “renal tubule”). The renal corpuscle filters out large solutes from the blood, delivering water and small solutes to the renal tubule for modification. About 20% of the blood plasma is forced out of glomerulus (specialized capillaries) and across the membrane Bowman’s capsule. It acts to filter some of the substances that are located in blood plasma from others. The renal tubule is the portion of the nephron containing the tubular fluid filtered through the glomerulus (University of Colorado, 2007). The components of the renal tubule are (Figure 1):

- Proximal convoluted tubule (PCT lies in cortex and lined by simple cuboidal epithelium with brushed borders which help to increase the area of absorption greatly)
- Loop of Henle (hair-pin like i.e. U-shaped and lies in medulla)
- The ascending limb of loop of Henle is divided into 2 segments: Lower end of ascending limb is very thin and is lined by simple squamous epithelium. The distal portion of ascending limb is thick and is lined by simple cuboidal epithelium.
- Thin ascending limb of loop of Henle
- Thick ascending limb of loop of Henle (enters cortex and becomes DCT-distal convoluted tubule.)
- Distal convoluted tubule (DCT)

1.2. Darcy’s Law

Darcy’s Law is a generalized relationship, which was indicated by Henry Darcy according to the results of experiments in 1856 (Darcy, 1856). It shows the discharge rate is a function of the flow area, elevation, fluid pressure and proportionality constant. Figure 2 indicates visual Darcy’s law.

As it is seen in equation (1) there is a simple proportional relationship between the instantaneous volumetric flow rate through a porous medium, the viscosity of the fluid and the pressure drop over a given distance (Goldberg, 1989).

\[ Q = \frac{-kA (P_a - P_b)}{\mu L} \]  \hspace{1cm} (1)

**Figure 1. Nephron anatomy**
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