Vendor Managed Inventory Problem for Blood Platelets: a Two Stage Deep Reinforcement Learning Approach

Andres F. Osorio[a], Juan D. Carvajal[b]

[a]*afosorio@icesi.edu.co*
[b]*juan030698@hotmail.com*

Abstract

This paper presents an application of Deep Reinforcement techniques

1. Introduction

2. Literature Review

3. Problem Definition

4. Methodology

The deep reinforcement learning model model was developed using the Tensorflow, the integer programming model was solved using pulp the integration was carried out using the Python

Feynman and Vernon Jr. (1963) Dirac (1953)

4.1. Two Stage Deep Reinforcement Learning Framework

In our framework, deep reinforcement learning is used to represent the actual of the blood centre, incorporating variability in donation and demand. Features such as perishability. Integer programming is used to support decisions concerning the allocation of blood platelets to the hospitals.

4.2. Deep Reinforcement Learning

$$Q(s_t, a_t) \longleftarrow (1-\alpha).Q(s_t, a_t) + \alpha.(r_t + \gamma.\max Q(s_{t+1}, a)) \tag{1}$$

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4.3. Integer Programming Model

Objective Function

$$\min \quad \sum_{h \in H} (I_{h0} CV + F_h CF) \tag{2}$$

Constraints

$$I_{h0} = \max(0, I_{h1} + X_{h1} - D_h) \tag{3}$$

$$F_h = \max(0, D_h - \sum_{r \in R} (I_{hr} + X_{hr})) \tag{4}$$

$$F_h \leq \frac{1}{\|H\|} \sum_{h \in H} (F_h) \tag{5}$$

$$A_r = \sum_{h \in H} (X_{hr}) \tag{6}$$

$$\frac{\sum_{r \in R} (I_{hr} + X_{hr})}{D_h} = \frac{\sum_{r \in R} (I_{h+1r} + X_{h+1r})}{D_{h+1}} \quad \forall h < 4 \tag{7}$$

Constraints 2 and 3 can be linearised as follows:
Linearisation Equation 2

$$-I_{h1} - X_{h1} + D_h \leq M * YI_{h0} \quad \forall \quad h \tag{8}$$

$$I_{h1} + X_{h1} - D_h \leq M(1 - YI_{h0}) \quad \forall \quad h \tag{9}$$

$$I_{h0} \geq 0 \quad \forall \quad h \tag{10}$$

$$I_{h0} \geq I_{h1} + X_{h1} - D_h \quad \forall \quad h \tag{11}$$

$$I_{h0} \leq M(1 - YI_{h0}) \quad \forall \quad h \tag{12}$$

$$I_{h0} \leq I_{h1} + X_{h1} - D_h + M * YI_{h0} \quad \forall h \tag{13}$$

Linearisation Equation 3

$$-D_h + \sum_{r \in R} (I_{hr} + X_{hr}) \leq M * YF_h \quad \forall h \tag{14}$$

$$D_h - \sum_{r \in R} (I_{hr} + X_{hr}) \leq M * (1 - YF_h) \quad \forall h \tag{15}$$

$$F_h \geq 0 \ \ \forall \ \ h \tag{16}$$

$$F_h \geq D_h - \sum_{r \in R} (I_{hr} + X_{hr}) \ \ \forall \ \ h \tag{17}$$

$$F_h \leq M(1 - YF_h) \ \ \forall \ \ h \tag{18}$$

$$F_h \leq D_h - \sum_{r \in R} (I_{hr} + X_{hr}) + M * YF_h \ \ \forall h \tag{19}$$

Once the model has been run, the inventory in each hospital is updated as follows:

$$I_{hr} = \max(0, I_{hr+1} + X_h - \max(0, D_h - \sum_{r \in R} (I_{hr} + X_{hr}))) \ \ \forall h, \ r \neq 0, 4 \tag{20}$$

$$I_{h4} = \max(0, X_4 - \max(0, D_h - \sum_{r \in R} (I_{hr} + X_{hr}))) \tag{21}$$

5. Case study

6. Results

References

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Feynman R., Vernon Jr. F. The theory of a general quantum system interacting with a linear dissipative system. Annals of Physics1963;24:118–73.