Optimization applied to work assignment in flower crops

Research Practice final Presentation

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About the industry

- Very important part of Colombian economy
- Largest supplier of the region and second worldwide
- Mainly supplies worldwide demand along with The Netherlands, Ecuador, and Kenya [ProColombia, 2016]

About the company

- Flores El Trigal
- Flower production business
- All processes involved in the production of the flowers
- Mainly focused on flowers of the chrysanthemum family
- Propagation and Production units

Settings

- Production of plant cuttings
- Crop of plants divided into blocks divided into beds
- Set of workers dedicated to harvesting plants each day
- Plants yield depending on age and frequency of harvest
- Orders placed weekly for different varieties of cuttings

Problem Statement

Assigning the routes through the beds and blocks which need to harvested by workers every day minimizing waste the amount of cuttings not fulfilled in every order.
Since Workers need to be supervised throughout the day by limited number of supervisors, assignment of workers to a group will also be accounted for in the problem.

Approach

The problem is to be approached by the formulation of a mathematical programming model associated and its implementation using the AMPL language.

Waste

Waste in terms of cuttings comes from different sources and its is not limited to cuttings themselves.

- Waste from storage
- Waste from harvest
- Waste from time used
- Waste from translation

Fulfillment

Fulfillment of the orders is a priority for the company. Orders not met must be completed the week after.

Previous Research

Optimization techniques have been widely used in the field of agriculture to solve several kind of problems coming from logistic processes, worker assignments, financial decisions, maintenance, etc.

- Routing Problems
  - Particle swarm optimization for machines in sugarcane fields [Sethanan and Neungmatcha, 2016]
  - Simulated annealing and genetic algorithms applied to motion of vehicles [Ferentinos et al., 2002]
- General production planning
  - Robust optimization in Citrus Company [Munhoz and Morabito, 2014]
  - Linear programming in crop rotation [Alfandari et al., 2015]
  - Programming accounting for ripeness in apples [Gonzalez-Araya et al., 2015]

Objective Function

$$Min : \sum_{d \in days} \sum_{v \in vars} UnF_{v,d} + sW_{v,d} + hW_{v,d} + timeW_d + transW_d$$

Factors added to each of the terms to represent how much of the cost of a cutting it represents.

Harvest

$$Harv_{v,d} = \sum_{bd \in beds} isH_{bd,d} * Q_{bd,d,v} * CPPf(d, v, age)$$

where $isH_{db,d}$ indicates weather the bed bd was harvested on day d, $Q_{bd,d,v}$ indicates the amount of plants of variety v on day d on bed bd and $CPPf(d, v, age)$ is a function that indicates a rate of cuttings per plant depending where in the cycle of harvest is the bed. The harvest yield the calculation of the unfulfilled orders and the storage waste.

Waste From Harvest

Waste calculated comparing the harvest done to the best of the week in cuttings per plant per days not harvested

$$hW_{v,d} = \sum_{bd \in beds} isH_{bd,d} * Q_{bd,d,v} * CPPDf(d, v, age)$$

where $CPPDf(d, v, age)$ is a function that calculates a factor based on the difference between the maximum rate of cuttings per plant per day and the rate of the day at which the bed is harvested and the amount of days that the bed has not been harvested.

Waste from time Used

Time taken in harvesting differs depending on the frequency of the harvest. Calculated similarly to the waste from harvest but having in account a rate of cuttings per hour harvested for each day not harvested and the maximum if them.

Waste from transportation

$$tansW_d = \sum_{bd1 \in beds} \sum_{bd2 \in beds} X_{bd1,bd2} * time(bd1, bd2) * SCPH$$

where $X_{bd1,bd2}$ indicates weather the route from bed $bd1$ to bed $bd2$ was used, $time()$ indicates the time taken to travel the route, and $SCPH$ is a standard rate of cutting harvested per hour.

Others

- Functions depend on state of the plant in the cycle of harvest.
- States modeled having in account if the bed was harvested the day before and in which state was the bed the day before with logical constraints in linear form.
- Limited set of states.
- Groups of workers selected by an average performance factor of the group.

Work in progress

- Tests with small examples
  - Verify
  - Validate
- Tests with small controlled scenarios

Future Work

- Tests with real data
- Expansion of model to account for storage dynamics
- Evaluation of model for computation time

Conclusions

- About mathematical programming models
- About linealization strategies

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Thank you