**THE OPEN UNIVERSITY OF SRI LANKA**
**FACULTY OF ENGINEERING TECHNOLOGY**
**THE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING**
**EEX5362 PERFORMANCE MODELLING**

# Mini Project
# Deliverable 01

# Optimizing an Automated Egg Collection System to Minimize Breakage and Energy Consumption

**Git:** https://github.com/ShahrulHaqPro/EEX5362-MP-322516498

M.N.Shahrul Haq
322516498
BSE Hons

## Problem Description

I'm focusing on optimizing an automated egg collection system to minimize breakage and energy consumption in a medium-large commercial egg farm. The system is an automated egg collection system with three 3-tier layer cages. The farm has 10,000+ laying-hens across three cages, each with 3 tiers and 2 sides (left and right), in total the farm has 18 independent conveyor belts as 6 belt per cage to transport eggs to a collection point.

The farm owner is facing a critical operational challenge such as many eggs breaking during the egg collection especial morning collection rush, and it gets even worse during hot months (temperatures of 30-35°C and above). So, they need to use the ventilation and cooling systems more often which increases the electricity utilization more. Nowadays electricity bills are so high. And we identified as a cause that the current collection system operates with a fixed belt speed that hasn't been optimized since start.

- Slow belt speeds cause eggs to accumulate on the belt. This leads to egg-to-egg contact, collisions, and overcrowding, and increases breakage rates.
- Fast belts operate with low utilization because the belt is often empty, and belt motors operate at high energy costs, this wastes electricity.
- Excessively high speeds cause eggs to shake, spin, and collide with cage or other eggs, it increases breakage.

The efficiency of this system has a direct and measurable impact on the profitability of the farm, and it lies in balancing the cost of broken eggs against the cost of energy consumption.

## This is a Complex System Because:

It's a complex system because several different factors interact dynamically

1. Egg laying is not constant, it follows a temporal distribution. The rate peaks in the morning and varies throughout the day. It creates a variable and unpredictable load on the conveyor belts.
2. External temperature directly affects the hen's laying rate and the total system load, and it creates a seasonal and daily performance variation.
3. The 18 belts share the same electrical infrastructure but may have slightly different loads. So, a single solution may not work perfectly for all of them.
4. The primary objectives of reducing breakage and reducing energy consumption are requiring a balanced, optimal solution..

## Dataset Description

For the model I require some data such as operational data, static and dynamic data about the farm. Some data that I collected/will collect using calculations and some using simulation as well.

## Data Collection:

| Data | Description |
|---|---|
| **Belt count** | Total number of belts |
| **Belt length** | Length of each belt |
| **Hens per belt** | Average number of hens per belt |
| **Motor power** | Power rating of each belt motor |
| **Timestamp** | Date and time of recording |
| **Temperature** | Ambient temperature |
| **Eggs laid count** | Number of eggs detected on a specific belt in a time interval |
| **Laying rate** | Estimated laying rate |
| **Belt speed** | Controlled speed of the belt |
| **Broken eggs count** | Number of broken eggs collected from a specific belt |
| **Breakage rate** | (Broken Eggs / Total Eggs Collected) * 100 |
| **Energy use** | Energy consumed by the belt motors in a time interval |

## Performance Objectives

The primary goal of my model is to develop a simulation model that can identify the optimal belt speed strategy to maximize farm profitability. This will be achieved by focusing on the following measurable performance objectives:

1. Minimize Egg Breakage Rate

$$\textbf{Breakage Rate} = \frac{\textbf{Number of Broken Eggs}}{\textbf{Total Number of Eggs Collected}} * \mathbf{100}\ \%$$

2. Minimize Energy Consumption per Egg

$$\textbf{Energy Efficiency (kWh/egg)} = \frac{\textbf{Total Energy Consumed by Belt Motors}e}{\textbf{Total Intact Eggs Collected}}$$

3. Maximize System Throughput

**Throughput (eggs/hour) = Number of damaged or spoiled eggs collected per hour.**

4. Identify and Quantify Bottlenecks.

$$\textbf{Belt Utilization} = \frac{\textbf{Time belt is transporting eggs}}{\textbf{Total operational time}} * \mathbf{100}\ \%$$

and

**Egg Density = eggs / meter**