

# Digital Twins of Refrigerated Trailers to Optimize Fresh Fruit Cold Chains

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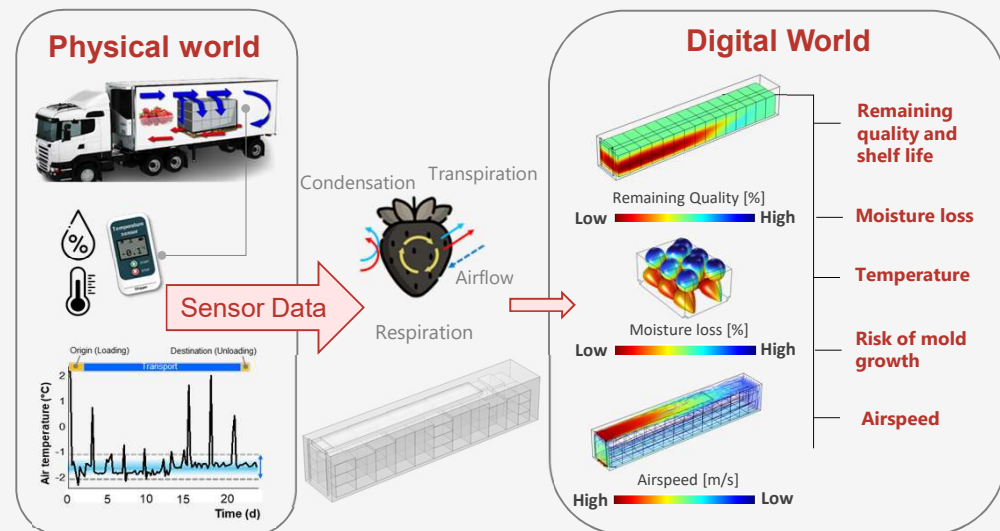
## 1 Background and Motivation

- Up to **one-third** of the world's horticultural produce is lost during transportation. These products are sensitive to temperature fluctuations and can quickly deteriorate.
- Sensors are used to monitor transports, but the data is rarely translated into controllable metrics.
- To better control and predict the quality of fruits and vegetables, we aim to create **physics-based digital twin systems** that mimic the evolution of fruit quality.



## 2 Digital Twin Approach

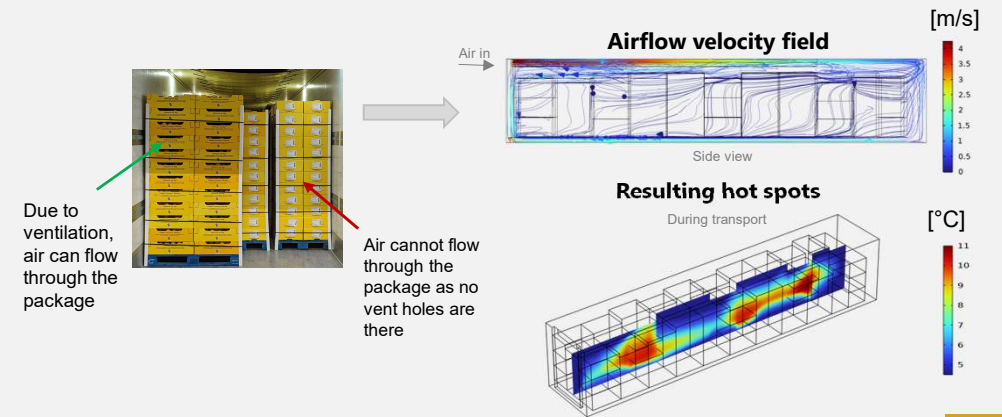
We translate real-time sensor data during refrigerated transport by trailer – in a mechanistic way – into **actionable fruit quality metrics** such as remaining shelf-life, mass loss, or microbiological spoilage.



## 3 Findings

### Effect of Packaging Design on the airflow field and heat transfer

**Homogeneous airflow** in refrigerated trailers is vital for maintaining consistent temperatures that align with fruits' preservation needs. **Packaging**, pallet placement, and ventilation of the packaging significantly affect temperature distribution. Inhomogeneous airflow inside the trailer can lead to hot or cold spots that harm fruit quality and shelf life.



## 4 Contribution to Sustainable Food Systems

- Digital Twins are a helpful tool in fresh-fruit supply chains. They can provide overall quality details and information about the durability of the cargo even if unplanned happens.
- Stakeholders along the chain can use it to react accordingly and **prevent damage** because it is possible to gain **dynamic visibility** in near-real time.
- Fresh fruit quality for retailers and consumers can be maximized while losses can be reduced.** Hence, Digital Twins in fresh fruit supply chains align with several Sustainable Development Goals.



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