

## Bejo Zaden @ Physics with Industry 2020

### High-precision non-destructive 3D-volumetric measurements of small objects (0.5-2mm)



#### 1. Company information

Bejo is one of the leading companies regarding the breeding, production and sales of vegetable seeds. Their primary Research and Business facilities are located in Warmenhuizen, the Netherlands, but they have sales/distribution offices all over the world. Their key business objective is the breeding of high quality food crops emerging from high quality seeds. By combining state of the art seed processing and seed treatments Bejo offers a wide range of products where quality has the highest priority. Bejo's main crops are *Brassica* (cabbage), *Daucus carota* (carrot) and *Allium*.

#### 2. Problem

In a changing world food availability is an increasing concern and a crucial priority. The supply of high quality seeds at an affordable price is needed to meet food demands in the 21st century. To meet these demands Bejo, and others, require next-generation state-of-the-art seed sorting methods to increase their supply chain efficiency and guarantee food produce for fair prices in the decades to come.

Seed lots (up to 600 kilos which translates to millions of seeds per batch) arrive at our warehouse in Warmenhuizen. These seeds need to undergo several cleaning and grading steps to finally yield a high-quality sellable product. Generally, the seeds need to be cleaned (removal of dirt and non-seeds), calibrated, coated and packaged. Calibration entails the passing of seeds lots over big sieves to remove low-quality seeds based on seed diameter.

After each individual processing step the seed quality is monitored by the Bejo Seed Analysis and Seed Health laboratories. It happens every so often that the quality after calibration is not up to the high-quality standard that Bejo seeks. The reasons for this can be diverse, ranging from unfortunate growing or harvesting conditions to the presence of unripe seeds in the produce. To increase quality, Bejo has several so-called 'upgrading' procedures available such as density-sorting, ripeness sorting (chlorophyll sorting) and sorting methods based on color or seed physical appearance. The trade-off is that quality upgrading demands a substantial loss in seed quantity as many (especially 'classical') sorting methods cannot discriminate with a 100% accuracy.

Bejo has a dedicated Research group to suggest the most suitable upgrading route, if needed, and to explore and/or develop new methods to increase seed quality and decrease the loss-of-seeds during processing. For the majority of seed types, which may differ significantly in appearance, density is an important quality-determining factor. Higher density seeds will generally be of higher quality when compared to low density seeds. Although Bejo possesses several methods to sort on density, none of these methods is solely dependent on density. The major used methods of seed-shaking-tables and density sorting by wind also discriminate on seed morphology such as seed smoothness and exposed seed surface area.

To obtain the highest-quality seeds at the lowest possible loss and with high-throughput (50-200 seeds measured/sorted per second or faster) during seed upgrading, it is crucial to obtain very precise measures of seed weight and volume to ultimately, and very accurately, determine seed density. Seed weight is difficult to determine at high speeds as seeds weigh very little (usually 3-10 mg) but seed volume may be determined through volumetric imaging methods. Imaging methods, using structured light or laser triangulation, are available for bigger objects such as parcels, suitcases and even agricultural products such as potatoes, but are considered very difficult, if not impossible, to adapt for very small objects. For this workshop we challenge the contestants to devise a method for volumetric measurements on the individual (single) seed level with a diameter of no more than 2 mm that has potential for high-throughput applications. If achieved, such method would have a major impact on seed-sorting efficiency and, ultimately, affordable seed prices. The focus for this workshop should be on measuring seed volume but other properties such as detection of seed shape anomalies (such as thresh damage) or surface structures (hairs or contaminants) would be of (future) interest.