

ESMERA FOOD PROCESING CHALLENGES

Food processing often involves working with natural materials and can require high throughput. The combinations of these two demands result in a difficult set of challenges for robotics and automation and explain the high numbers of people employed in seemingly “simple” tasks in the industry. To meet these challenges any robotics or automation must be capable of identifying features, such as grasp points, on plant or animal based material which may vary considerably between items; having identified grasp positions the robot must affect a grasp that will differ from item to item without causing damage; and finally the machine must operate at human speeds or greater in carrying out these operations.

ESMERA has identified several industrial challenges and classified the needs for further technical advances in 2 main challenges. Under each Food Processing challenge ESMERA propose two options of industrial challenges that can be solved, option a) ESMERA proposed challenge and option b) Open challenge

Food Processing Challenge 1: Flexible manipulation system for poultry or fish handling

The process identified for automation is poultry hanging in the slaughterhouse line or fish handling is highly labor intensive and the automation of this operation have not fully managed so far.

As defined in the [Robotics 2020 Multi-Annual Roadmap](#), the key abilities that are paramount for this challenge are:

- **Perception ability:** Animals vary considerably in their features and distinguishing candidate food items to pick, at high throughput rates, presents several challenges. Key amongst these are:
 - Identification of pickable and appropriate items, when the items exhibit natural variation and are overlapping.
 - Identification of usable grasp points and approach trajectory.
- **Manipulation ability:** Due to the natural variation, there can be no “one size fits all”, approach towards picking. Both the gripping system design and the grasp algorithms will have to adapt to each item.
- **Dependability:** The system will need to work at high speeds to match line speeds and minimise breakdowns, as these will be costly. The ability to work for long periods without a failure or slowdown in performance is a key requirement.
- **Motion ability:** For tasks such as the dried cod picking and movement, the ability to navigate within a storage area will be a key attribute of the system.

It is expecting from the solution to fulfill the following metrics:

- **Ability for identifying the items:** Identification of the status of item to be grasped from among a number of similar items. Given that the items are animals (i.e. either poultry or fish) then the status check involves identifying individual animals and assessing their status to be picked.
- **Dexterous grasping:** Identifying suitable grasp points on the item. This can be seen as a complex version of the bin-picking problem where a whole animal must be picked from a tray or conveyor belt of similar animals using grasp points that both enable a secure grasp to be affected and which allows the desired placement objective to be achieved.

- **Manipulation capability:** Affecting a grasp and moving the item to a pre-defined location. The end location may be a fixed location such as a tray (in which case a desired placement pattern must be achieved) or a moving location such as a conveyor hanger (in which case the hanger must be tracked while the insertion takes place).

Under the above challenge, ESMERA proposes several options. The proposer must address at least one of these challenges although addressing more than one or highlighting where elements of the proposed system could be used for the benefit of more than one system would be beneficial.

A) ESMERA proposed challenges: this challenge is extracted from *three* industrial use cases which are:

FOOD PROCESING CHALLENGE 1.A1 (FP1.A1)

Transfer of chicken to hanger conveyor.

Although the processing of chickens is automation intensive, the transfer of chickens on a conveyor belt to a hanger conveyor (hung by their feet) is a completely manual process. The demands on automation in this task are high. The chickens enter the area on a conveyor from the stunning area. A first check needs to be undertaken that the chickens are stunned but not dead. Any dead chickens need to be rejected. Next the chickens need to be individually grasped (manually this is by the feet) and their feet placed securely in the moving hanger conveyor. To be competitive the system needs to complete these operations at the rate of 1250 birds per hour or approximately one every 3 seconds.



Figure 1: Chickens on hanger conveyor

FOOD PROCESING CHALLENGE 1.A2 (FP1.A2)

Fresh fish picking: The fresh fish arrive in large trays on a conveyor. The task is to transfer the fish to smaller trays ensuring that the total weight of the packed second tray is kept within specified limits. The task involves identifying suitable fish to pick, establishing good grasp points and achieving a stable grasp that does not damage the fish. As well as identifying fish that can be successfully picked from the input tray, the system will be required to assess the likely weight of the fish (particularly towards the latter part of filling an output tray) to minimise any trial and error adjustments of weight.



Figure 2: Fresh fish in trays

FOOD PROCESING CHALLENGE 1.A3 (FP1.A3)

Dry cod fish picking. The dry cod needs to be picked from a stack of dried cod at one point in the store and transfers the cod to another location. Units of cod can weigh up to 10kg. The system needs to identify suitable grasping points and undertake a suitable grasp without damaging the cod while ensuring a stable grasp is attained.



Figure 3: Example of a dried Cod fish, weighing from 3-10 kg's.

B) Open challenge (FOOD PROCESSING CHALLENGE 1.B (FP1.B))

Any other proposal for similar technologies is eligible for funding, provided that a thorough explanation of the industrial needs is presented. The proposals will also have to clearly identify the state of the art in commercially available solutions and highlight the differences/advances over it. More specific each proposal in order to be in line with the ESMERA requirements has to provide:

- Clear indication of the company, institution or other that are in need of the proposed solution (no funding is allocated to challenge providers)
- Description of the problem that the company or companies need to be solved.
- Proof that currently there is no comparable solution (concept or approach, performance, cost...) in the market.

Food Processing Challenge 2: Cobot for assisted picking of food items.

This challenge consists of the development of a cobot to work under the direction of a worker in the movement of heavy foodstuff either on a food processing line or within a food warehouse.

As defined in the [Robotics 2020 Multi-Annual Roadmap](#), the key abilities that are paramount for this challenge are:

- **Interaction ability:** The cobot has to interact with the operator during the process. The interaction may be at the physical level, e.g. being directed to an end location, or through a control interaction, e.g. the cobot may be instructed to pick a specific piece of cod. The robot will also have to be aware of other workers in the vicinity and proceed to carry out all movements safely.
- **Manipulation ability:** Due to the natural variation, there can be no “one size fits all”, approach towards picking. Both the gripping system design and the grasp algorithms will have to adapt to each item. Even where an item to be picked is identified by an operator the grasping operation can be complex.
- **Motion ability:** For tasks such as the dried cod picking and movement, the ability to navigate within a storage area will be a key attribute of the system.
 - **Perception ability:** Where the robot is required to identify appropriate items to be picked the natural variation can make the process difficult. Even where items to be picked are chosen to be the operator, the cobot still has to identify suitable grasp positions and strategies.

- Identification of pickable and appropriate items, when the items exhibit natural variation and are overlapping.
- Identification of usable grasp points and approach trajectory.

It is expecting from the solution to fulfill the following metrics:

- **Dexterous grasping:** Effecting a suitable grasp while dealing with naturally variable foodstuffs.
- **Manipulation capability:** Finding the end location to which the item needs to be moved, either through querying a warehouse / production management system or directly from an operator.
- **Collaborative and safe:** Working in the close vicinity of an operator and other workers while picking and transporting potentially heavy items of foodstuff.

Under the above challenge ESMERA project proposes two options. The proposer must address at least one of these challenges although addressing more than one or highlighting where elements of the proposed system could be used for the benefit of more than one system would be beneficial.

A) ESMERA proposed challenges: this challenge is extracted from *one* industrial use case which is FP1.A3 above, but which involves more operator oversight:

FOOD PROCESING CHALLENGE 2. A1 (FP2.A1)

Dry cod fish picking cobot. The dry cod needs to be picked from a stack of dried cod at one point in the store and transfers the cod to another location. The items to be picked may be identified by the system or by an operator. However, picking will be autonomous. The transportation may be autonomous to a position specified by the operator or may involve the operator leading / driving the cobot to the end location. Once at the end location the cobot is to place the cod in the designated tray. Units of cod can weigh up to 10kg. The system needs to identify suitable grasping points and undertake a suitable grasp without damaging the cod while ensuring a stable grasp is attained.



Figure 4: Example of a dried Cod fish, weighing from 3-10 kg's.

B) Open challenge (FOOD PROCESSING CHALLENGE 2.B (FP2.B))

Any other proposal for similar technologies is eligible for funding, provided that a thorough explanation of the industrial needs is presented. The proposals will also have to clearly identify the state of the art in commercially available solutions and highlight the differences/advances over it. More specific each proposal in order to be in line with the ESMERA requirements has to provide:

- Clear indication of the company, institution or other that are in need of the proposed solution (no funding is allocated to challenge providers)
- Description of the problem that the company or companies need to be solved.
- Proof that currently there is no comparable solution (concept or approach, performance, cost...) in the market.