

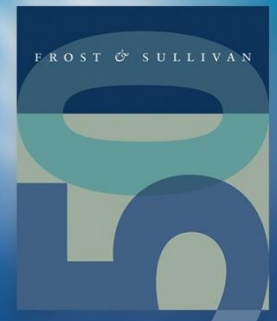
# Advanced Manufacturing Technology (TechVision)

## Robots as Next-Generation Chefs

“Robot Chefs Capable of Cooking Food”

D718-TV

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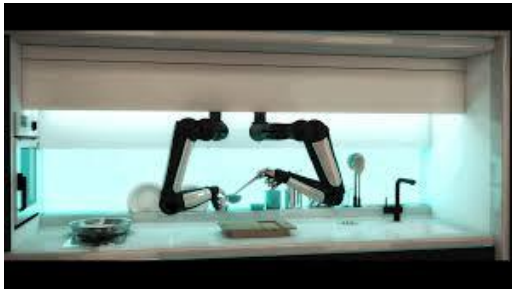
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# Innovations—Robot Chef to Prepare Food

# Moley Robotics–MK1 The Robotic Kitchen

Robotic arms programmed to cook meals and then clean the cooking station

The MK1 is a robotic kitchen which consists of two robotic arms and hands, an oven, a dishwasher, a cooking unit and a touchscreen. The robotic arms and hands are embedded with advanced tactile sensors which allow them to switch the stove, oven and dishwashers on and off and at the same time stir, clean, chop and use the utensils properly.



## Competing Aspects

- ✓ Integrated and easy cooking.
- ✓ Good food quality and taste.
- ✓ Efficient usage of cooking workstation .
- ✓ Three dimensionally recorded cooking skills

## Technology Readiness Level

1 2 3 4 5 6 7 8 9

Moley Robotics is currently working on optimizing the prototype of MK1 kitchen. Future version are expected to have motion capture cameras. More recipes can be downloaded and prepared using the three-dimensional recipe recording system. The company is developing and preparing this novel technology according to food industry standards.

## Attributes of Innovation

This robotic kitchen is capable of cooking pre-loaded meals and then cleaning up the cooking station afterwards. Master Chef Tim Anderson's cooking skills are at present three dimensionally recorded into the system and the robotic hands can exactly imitate the cooking movements. The robot has 20 motors, 24 joints, 129 sensors.

## Market Readiness and Commercialization Strategy

✓ Moley Robotics is currently in discussion with housing developers and builders, which will allow home buyers to opt for incorporating the MK1 unit in their houses.

## Commercialization/Wide-scale Adoption Year

Moley Robotics has decided to launch MK1 for sale by the fourth quarter of 2017. Particularly with expanding capabilities such as vision, it has opportunities to gain market presence or traction around 2020.

## Impact on Industries/Specific Applications

This novel technology has opportunities to impact the food and construction industries. Many restaurants and households could adopt this technology for cooking purposes. The construction industry has potential to install these robotic kitchens instead of modular kitchens in the future.

## Market Opportunity

- ✓ Food
- ✓ Construction
- ✓ Space
- ✓ Military
- ✓ Consumer/household

## Technology Convergence

The robotic arm and hands, new software interface and system, new programming platform, and the kitchen unit on the whole can open up new application opportunities in the above industries.

Impact & Opportunities

# Xtronik/Tomsk State University of Control Systems and Radioelectronics (TUSUR)-Tomsk Robot Chef

## Humanoid robots capable of preparing and cooking food

This robot is capable of moving with ease in a 3D space and at the same time can complete various culinary stages required to prepare a meal. This robot is designed to prepare fast food and replace workers in restaurants.

### Technology Readiness Level

1 2 3 4 5 6 7 8 9

At present, the research team is still optimizing the first test model to enable better efficiency and ensure precise programs are followed according to varying situations while cooking.

### Attributes of Innovation

This robot does not require any specially designed workstation and is capable of adapting to the cooking environment. The robot is also installed with different manipulators to perform different culinary operations required to prepare fast food and can interact with other machines and equipment. Subsequently, the robot will be equipped with vision.

### Market Readiness & Commercialization Strategy

The research group has primarily developed the robot to assist in restaurants, cafes. This might eliminate the requirement for excess manpower in restaurants.

Impact & Opportunities

### Commercialization/Wide-scale Adoption Year

The research team is currently optimizing the robot for better performance under varied circumstances in a restaurant or cafe. A test model of the robot chef will be presented in 2016 and the technology is expected to be ready for commercialization by 2018 or 2020.

### Impact on Industries/Specific Applications

This novel innovation can provide many new applications and solutions for the food industry. It can efficiently increase food preparation standards. From the marketing aspect, more customers might come to the restaurant just to watch the robot cook. Also, the robot can be more reliable than human workers and is able to work at a constant speed.

### Market Opportunity

- ✓ Food
- ✓ Military
- ✓ Space

### Technology Convergence

Such robots require advanced programming systems, sensors, and auxiliary circuits. This will lead robot and sensor companies to design and develop special equipment for robots, especially to serve the requirements of the food industry.



### Competing Aspects

- ✓ Does not need a special environment to work and cook food
- ✓ Better efficiency and standards when compared to restaurant workers.
- ✓ Can replace man-power requirements in restaurants
- ✓ Can perform multiple tasks with ease

# Yaskawa–Motoman SDA10 Dual Arm Robot

Industrial robot used for preparing food using special grippers as arms

Though this robot is designed for industrial purposes, it is programmed to cook using the Robotiq universal gripper. It has the capability to open the fridge, take the groceries and even use the egg cracker tool to break the eggs. This seven axis robot can be programmed to cook basic meals.

## Technology Readiness Level

1 2 3 4 5 6 7 8 9

Though this robot is basically used for industrial assembly (e.g., picking and packing), it can be programmed to perform basic culinary processes with the Robotiq universal grippers.

## Attributes of Innovation

The SDA 10D is a 15-axis robot (with dual 7-axis arms) with a payload of 10kg. The cables of the robot are routed in such a manner that they do not interfere with the movements of the robot. A DX100 controller is used for controlling and programming the robot.

## Market Readiness & Commercialization Strategy

Yaskawa developed the SDA10 as an industrial robot, but has incorporated the universal gripper and modifications in the program to control the robot to perform small culinary tasks.

## Commercialization/Widescale Adoption Year

The robot was commercialized for industrial purposes as a pick and place robot. It has, however, been demonstrated for applications such as cooking an omelette..

## Impact on Industries/Specific Applications

This robot has the capability to impact the food industry, but at the same time requires more design improvements and development according to the requirements of the food industry.

## Market Potential/Opportunity

- ✓ Food
- ✓ Military
- ✓ Space
- ✓ Automotive

## Technology Convergence

Though this robot can cook, it is also an industrial pick and place robot. The arms of the robots can be changed and used for other industrial purposes.

Impact & Opportunities



## Competing Aspects

- ✓ Higher accuracy and precision
- ✓ Increased efficiency
- ✓ Increased job standards
- ✓ Easy to programme
- ✓ Universal gripper facility

# Sereneti-Sereneti Kitchen

## Robotic kitchen unit to cook meals easily and quickly

The Sereneti kitchen station consists of a robotic arm which can be programmed to perform culinary processes to prepare a meal. The kitchen is a separate unit with a robotic arm which will be able to move around the unit with ease. Users need to clean and chop the vegetables and place them in a bowl for the arm to start the cooking process.

### Technology Readiness Level

1 2 3 4 5 6 7 8 9

The company is still in the design and development stage of the kitchen unit. Different innovations and techniques are being implemented to optimize the performance of the kitchen unit.

### Attributes of Innovation

The kitchen unit consists of several advanced sensors for the robot to sense and perform culinary tasks. The robotic arm itself has various axes and collision sensors which allow it to move with ease without colliding with any object in the environment.

### Market Readiness & Commercialization Strategy

The company first developed the robot called Cooki which was only able to stir the food. To further develop the Sereneti kitchen and scale up production, the company has started a crowd funding campaign on Indiegogo

### Competing Aspects

- ✓ Time taken to cook a meal is less
- ✓ Eliminates requirement of manpower
- ✓ High efficiency and precision in cooking meals with standard quality



### Commercialization/Wide-scale Adoption Year

At present, the kitchen unit is in the design and development stage; the company expects to unveil the product in the food market by the second quarter of 2018. Adoption of this technology can be expected by the end of 2020.

### Impact on Industries/Specific Applications

This novel technology will predominantly impact the food and the construction industry. Restaurants can install these kitchen units to improve restaurant standards and efficiency. Construction companies can install these robotic kitchen units in the houses they build.

### Market Potential/Opportunity

- ✓ Food
- ✓ Construction
- ✓ Space
- ✓ Military
- ✓ Consumer/household

### Technology Convergence

This technology can also be incorporated by the military and the space sectors to prepare food for soldiers and astronauts. It could also impact the sensor and robot industry. More innovations with regard to the food industry can be expected.

Impact & Opportunities


# Strategic Perspectives



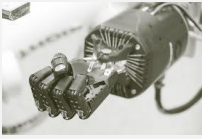
# Technology Convergence—Robots to Cook Food

## Robotic kitchen units and chefs to cook meals with ease


**Advanced Sensors**



**Robotic Arms/ Humanoids**



**Robots**



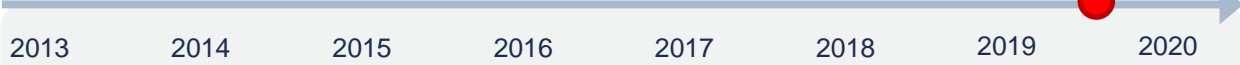

- >  **High efficiency**
- >  **Standards maintained**
- >  **Elimination of manpower**
- >  **High accuracy and precision**

### Industry Initiatives

Advancements in autonomous robotics, sensors (including tactile or force sensors), to better mimic movement of human hands, navigation, robotic components, and software are enabling robotic kitchen or chefs to streamline and reinvigorate food preparation.

### Year of Impact—2017-2020

Such novel technology has opportunities to be commercialized and impact the food industry around 2020.



# Analyst Perspectives

## Robot Chefs to Enter the Food Industry

### Innovation Ecosystem Strength

Currently, there are a few companies focused on developing robot kitchen units or robotic chefs. Some restaurants have already started using, or have demonstrated, robotic arms programmed to perform basic culinary processes. Innovations in robots specially developed for cooking and assisting in restaurants is emerging and is expected to gradually increase in the coming years.

### Impact of Regulations/Standards

As the robot will be cooking the food, it is expected that food standards will be maintained constantly. The Food and Drug Administration (FDA) and municipal Health and Hygiene Departments will be working on new regulations and standards for robots implemented in the food industry.

### Business Models

The initial cost of implementing robots and new smart kitchens will be relatively high. Component manufacturers, restaurant owners, and other users will have to adjust their business model to integrate such technologies to sustain profits. One scenario may be less human workers.

## Perspectives

### Target Markets—Near-, Medium- & Long- Term

- The food industry is the main target market, and the technology is expected to make an impact in this market in the near future, especially if further advances are made in allowing such robots to more precisely mimic human touch and human hands. .
- The kitchen units are also designed and developed to be installed in new buildings and houses; and a medium term impact is expected on the construction industry.
- This novel technology can also be adopted by the space and military sectors in the future.

### Adoption Barriers

- The technology needs further research and development in areas such as sensing, software, signal processing, according to the requirements of the food industry.
- The design and development cost is high which in turn also increases the initial cost of implementing this technology.
- The smart kitchen units are robots that need periodic maintenance to prevent efficiency and performance drops. Maintenance activities like changing sensors and cables can also incur high cost.

### Patent & Funding Trends

Patents and funding are focused on the development of robot smart kitchens and single robots with basic culinary skills. New sensors and three-dimensional motion scanners are also being innovated and patented. A major part of the funding is towards development and building the robotic arms and robots. Most of the patents in relation to this area are filed from China followed by the US.

# Appendix

# Key Patents—China

| No.  | Patent No.  | Publication Date | Title                      | Assignee   |
|--|-------------|------------------|----------------------------|--|
| 1  | CN104433829 | March 25, 2015   | Cooking robot              | Nanjing Dawu Education And Technology Co., Ltd.          |
| <p>The invention relates to a robot which is composed of a seasoning rotating device (1), a food material rotating device (2), a rotating main shaft (3), a weighing sensor (4), a material taking device (5), a material outlet (6), a data transmission device (7), a special cooking pan (8), a temperature sensor (9), a stir-fry tool (10) and an industrial control device (11). According to the working principle, movement of the whole machine is controlled by the industrial control device (11); when vegetables needing to be dried are selected by a user, the cooking robot begins to work, the standard ingredient and the standard mass will be selected by the cooking robot according to menus; the rotating main shaft (3) rotates to drive the seasoning rotating device (1) and the food material rotating device (2) to conduct multi-angle position conversion; and only food materials and seasonings in given transmission masses can be added by the material taking device (5) according to pressure transmission of the weighing sensor (4). The material taking intelligence is achieved.</p> |             |                  |                            |  |
| 2  | CN103753545 | April 30, 2014   | Dish cooking service robot | Chengdu Vonxan Automation Science & Technology Co., Ltd. |
| <p>The invention discloses a dish cooking service robot applied to families or restaurants. The dish cooking service robot is characterized in that the dish cooking service robot comprises synchronous driving wheel feet, a man-machine intercom system, a multifunctional mechanical arm and a 3D visual system, wherein the synchronous driving wheel feet, the man-machine intercom system, the multifunctional mechanical arm and the 3D visual system are respectively and independently connected with and are in bidirectional data transmission with a data processing module. The dish cooking service robot has the advantages that the dish cooking service robot achieves automatic vegetable cleaning, cutting, cooking and serving in a dish cooking process, a manual dish cooking mode is improved into a robot full-automatic cooking mode, influences on dish cooking efficiency by various important factors are avoided, efficiency of dish cooking is improved greatly, labor and time cost of the restaurants are saved, and waiting time of a user for dining is saved.</p>                        |             |                  |                            |  |

# Key Patents—World and Japan

| No.   | Patent No.   | Publication Date   | Title  | Assignee                               |
|---|--------------|--------------------|--|--|
| 3   | WO2014143615 | September 18, 2014 | Cooking Apparatus With Robotic Arm                     | Carrier Commercial Refrigeration, Inc. |
| <p>A cooking apparatus includes a base including a lower heating plate and an upper heating unit including an upper heating plate. The cooking apparatus includes a robotic arm connected to the upper heating unit to move the upper heating plate between at least a cooking position adjacent to the lower heating plate and a non-cooking position separated from the lower heating plate based on a control program.</p>   |              |                    |  |  |
| 4   | JP2009106734 | April 30, 2009     | Cooking Assistance Robot And Cooking Assistance Method | Panasonic Corp                         |
| <p>PROBLEM TO BE SOLVED: To provide a cooking assistance robot and a cooking assistance method capable of efficient mixing, with which ingredients are unlikely to be unevenly heated.</p> <p>SOLUTION: The cooking assistance robot for cooking by physically moving ingredients in a cooking container selects a mixing direction for leveling a mountain and performs a mountain leveling operation in the selected mixing direction in the presence of a mountain of a specified height or higher in the cooking container.</p> <p>COPYRIGHT: (C)2009,JPO&amp;INPIT</p> |              |                    |  |  |

# Industry Contacts

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