ROBOTIC VISION TECHNOLOGIES

PATENT PORTFOLIO

RVT's patent portfolio covers technology that has been developed and enhanced over the last ten years as well as new technology currently under development and use. Vision Factory [VF], is the brand name of the software that RVT licenses. It allows users to create scalable and robust vision guidance systems for industrial and non-industrial robots.

ISSUED PATENTS

1. **Method and Apparatus for Single-Camera 3D Vision Guided Robotics** (US 6,816,755)
   A technique of picking five unique features on an object in order to identify and track it in real time. The first single camera 3D patent of its kind in the world.

2. **Method and Apparatus for Single Image 3D Vision Guided Robotics** (US 8,095,237)
   A technique to train a vision system to recognize the location of a reference object so that an accurate 3D position may be calculated. The location is passed to a robot for further work.

3. **System and Method of Three-Dimensional Pose Estimation** (US 7,957,583)
   A technique for training a software using multiple 2D images that translate into a 3D object pose.

4. **System and Method of Determining Object Pose** (US 8,437,535)
   Covers the validation tools that are built into Vision Factory -- Auto Calibration (AutoCal), Automatic System Training (AutoTrain), and Automatic System Testing (AccuTest).

5. **Method and Apparatus for Machine Vision** (US 7,336,814)
   Covers the mathematical foundation behind the validation tools in patent 4.

6. **Methods and Apparatus to Facilitate Operations in Image Based Systems** (US 8,559,699)
   A technique to ensure that bins are picked until empty. These parts can be randomly placed in the bin and completely unstructured.

7. **System and Method of Detection and Tracking of Item Features** (US 9,734,401)
   A technique to automatically determine good edges to use as features. Features are edge patterns used as anchor points in 3D pose calculations. This patent also covers automatically controlling the light conditions in a work cell based on changes in ambient light.

8. **System and Method of Sensor-Based Safety Features for Robotic Equipment** (US 9,740,193)
   A technique, called Safety Net, for using a camera to detect an object coming within contact range of a robot. Zones can be designated where the robot would either slow down or stop. This is used for operator safety.

ISSUED PATENTS, IN EXCLUSIVE COLLABORATION

1. **System and Method of Distance Determination between RFID Tags** (US 9,767,330)
   A technique using a mesh of inexpensive passive RFID tags to triangulate by radio signal flight times the location of each tag. This is then used to find the position of the robot or a part of interest.

2. **System and Method of Foreground Motion Detection in compressed Video Data** (US 9,712,828)
   A technique in which a high-speed vision system, such as safety cameras, use compressed video to maintain a high frame rate while ignoring the background and only processing foreground objects of interest.

3. **3D Object Rotation-Based Mechanical Parts Selection through 2D Image Processing** (US 9,934,563)
   A technique using white balancing and object-rotation in machine vision systems to recognize locations of 3D objects with 2D images.

4. **Orientation-Based Hashing for Fast Item Orientation Sensing** (US 9,969,514)
   A technique in which a hash table of pre-computed parts in a finite number of poses is used to reduce the vision system cycle time by over 10X in cases where the parts come in a known set of orientations.

5. **Incidental Robot-Human Contact Detection** (US 9,868,213)
   All animal life generates small vibrations in a particular range of frequencies. By mounting inexpensive sensors on a robot contact with a human being can be detected and the robot stopped safely.

6. **Stable Grasp Point Selection for Robot Grippers with Machine Vision & Ultrasound Beam Forming** (US 9,889,564)
   A technique that utilizes feedback from a 3D vision system or ultrasound measurement to select grasping points on an object. Enables robot to adapt pick positions on the fly.

7. **Coordination of Multiple Structured Light-Based 3D Image Detectors**
   Patterns of structured light other than simple laser lines are created that increase the accuracy and speed the 3D vision computation can take place by overlaying multiple colors and type of line and dot patterns on a smooth featureless part.

PATENTS PENDING

1. **Three-Dimensional Imaging Sensor Calibration**
   A unique pattern of multi-colored laser illumination is used to simultaneously calibrate and operate a machine vision system on smooth or featureless parts such as spheres or wheels

2. **Alignment Markers to Facilitate Detection of Object Orientation and Deformation**
   Some parts are particularly difficult to recognize and handle by vision systems, especially parts that might be flexible, crushable, or devoid of features. This technique allows the machine vision system to adapt its selection of gripping points to handle bins of parts or parts that are flexible such as rubber or food.