493 RESARCH ARTICLES

KEYWORDS: ROBOTIC ARM, AGRICULTURE, COMPUTER VISION.

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# "Control and Dynamic Simulation of Wire-Driven Precise Spray Robotic Arm"

**Research topic:** This article proposes a new type of robotic arm for precise pesticide spraying in citrus orchards.

* **Technology:** Wire-driven robotic arm
* **Method:**
  + Uses two segments and wires to achieve bending and movement in two directions.
  + PD control ensures precise movement.
  + Joint state observers predict joint positions and speeds for improved control.
  + Dynamic simulation helps optimize performance.

**Benefits:**

* Precise spraying reduces pesticide waste and environmental pollution.
* Bendy arm allows for maneuvering around leaves and branches for targeted spraying.

**Significance:**

* This design offers a potential solution for more efficient and environmentally friendly pesticide application in citrus farming.

# "Recognition and Localization Methods for Vision-Based Fruit Picking Robots: A Review"

**Research topic:** This article reviews the application of machine vision for fruit picking robots.

* **Techniques and methods:**
  + Machine vision with algorithms for:
    - Localization (finding fruit position)
    - Target recognition (identifying fruit type)
    - 3D reconstruction (building a 3D model of the fruit)
  + Digital image processing techniques (traditional computer vision methods)
  + Deep learning-based algorithms (cutting-edge AI for image recognition)

**Key findings:**

* Machine vision improves efficiency and functionality of harvesting robots.
* Challenges exist for achieving high accuracy in real-world conditions, such as:
  + Varying lighting
  + Fruit obscured by leaves or branches
  + Robots operating in dynamic environments

**Future directions:**

* Research to improve:
  + Recognition and localization success rates under challenging conditions
  + 3D reconstruction accuracy
  + Fault tolerance of vision systems in complex environments

**Significance:**

* This review highlights the potential of machine vision for robotic fruit harvesting and identifies areas for future development.

# "Adaptive Visual Servoing for Obstacle Avoidance of Micro Unmanned Aerial Vehicle with Optical Flow and Switched System Model"

**Research topic:** This article proposes a vision-based system for obstacle avoidance in micro unmanned aerial vehicles (MUAVs).

* **Techniques and methods:**
  + Visual servoing: Uses camera information to control flight path.
  + Optical flow: Analyzes motion in camera image to estimate distance to obstacles.
  + Multi-thread processing: Ensures reliable and continuous processing of camera data.
  + Switched system model: Accounts for different flight modes during obstacle avoidance.
  + Adaptive control scheme: Adjusts flight path based on real-time obstacle detection.

**Evaluation:**

* Simulations and experiments demonstrate the effectiveness of the system in avoiding obstacles.

**Significance:**

* This system offers a potential solution for safe and autonomous navigation of MUAVs in complex environments.

# "Design and performance of a robotic arm for farm use"

**Research topic:** This article describes the development and evaluation of a 4-degree-of-freedom robotic arm for harvesting heavy-weight crops.

* **Technology:** Articulated robotic arm
* **Method:**
  + Design focuses on cost-effectiveness and functionality for agricultural environments.
  + 4-degrees-of-freedom allows for maneuverability.
  + Kinematic and dynamic aspects are considered for real-world performance.
  + PLC system is used for control.

**Performance:**

* Payload capacity: 0.21 times its own weight
* Average accuracy: 1.85 millimeters
* Repeatability: ±0.51 millimeters
* Offers a workspace volume of 8.27 cubic meters with a reach of 1.36 meters.

**Benefits:**

* Designed for efficient harvesting of heavy crops like pumpkins and watermelons.
* Offers potential for use in other industries with minimal modifications.

**Significance:**

* This robotic arm design contributes to automation in agriculture, addressing labor shortages and potentially improving efficiency.

# "Kinematics Analysis and Simulation of A 5DOF Articulated Robotic Arm Applied to Heavy Products Harvesting"

**Research topic:** This article presents the design and simulation of a 5-degree-of-freedom robotic arm for harvesting heavy crops.

* **Method:**
  + Kinematic analysis using Denavit-Hartenberg method for movement and positioning.
  + Solidworks 2014 software for design and component analysis.
  + Standard mechanical formulas for dynamic analysis.

**Design:**

* 5DOF articulated robotic arm for mounting on a robot tractor.
* Focuses on reducing torque requirements for efficient operation.
* Materials and motor placement are optimized to minimize torque.

**Performance (simulation results):**

* Achieved significant torque reduction (29.7% to 68.9%) through design optimization.
* Maximum reach: 1421 mm from base, 2026 mm from attachment point.
* Inverse kinematic analysis confirms good operational performance.

**Significance:**

* This design offers a potential solution for automated harvesting of heavy crops, reducing strain on farmers and potentially improving efficiency.

# "A Novel Machine Learning based Autonomous Farming Robot for Small-Scale Chili Plantations"

**Research topic:** This article proposes a machine learning-based autonomous robot for use in small-scale chili plantations.

* **Technology:**
  + Machine learning for pest and disease detection
  + Image processing for nutrient deficiency identification
  + Robotics for autonomous navigation
  + Sensors for data collection

**Method:**

* The robot uses a camera to capture images of chili plants.
* Machine learning algorithms analyze the images to identify pests, diseases, and nutrient deficiencies.
* The robot can autonomously navigate through the plantation using robotics techniques.
* A mobile application provides a user interface for controlling and monitoring the robot.

**Benefits:**

* Early detection of pests and diseases can help prevent crop losses.
* Identifying nutrient deficiencies allows for targeted fertilization.
* Automation can reduce labor costs and improve efficiency.

**Significance:**

* This system offers a potential solution for improving crop health and yield in small-scale chili farming.
* The approach could potentially be adapted for use with other crops as well.

\* 3D -> 2D

# "Co-robotic harvest-aid platforms: Real-time control of picker lift heights to maximize harvesting efficiency"

**Research topic:** This article proposes a co-robotic system to improve efficiency in fruit harvesting using orchard platforms.

* **Technology:** Co-robotic harvester with adjustable platforms
* **Method:**
  + Uses a vision system to estimate fruit distribution ahead of the harvester.
  + Sensors in picking bags measure each worker's picking speed.
  + A model-based control algorithm adjusts the platform heights based on:
    - Incoming fruit load (abundance of fruit to be picked)
    - Worker picking speed
  + This adjusts fruit picking supply (worker availability) to match fruit picking demand (amount of fruit to be picked).

**Benefits:**

* Improves efficiency by matching worker effort to fruit availability.
* Achieved a 9.5% improvement in harvesting throughput in apple orchard trials.

**Significance:**

* This co-robotic system offers a potential solution for increasing productivity in fruit harvesting while reducing manual strain on workers.

\* Prototype

# "Tomato Harvesting Arm Robot Manipulator; a Pilot Project"

**Research topic:** This article describes a pilot project for a robotic tomato harvester.

* **Technology:** Robotic arm manipulator with image processing
* **Method:**
  + Uses a simple image processing algorithm to detect red and green tomatoes.
  + The location of the tomato determines the movement of three servo motors controlling the arm.
  + The arm extends towards the detected tomato and harvests it.

**Performance:**

* Achieved successful harvesting of tomatoes in a controlled setting.
* Average harvesting time:
  + Red tomato: 4.932 seconds
  + Green tomato: 5.276 seconds
* Total cycle time (including return to standby position):
  + Red tomato: 9.676 seconds
  + Green tomato: 10.586 seconds (slower due to robot positioning, not color)

**Significance:**

* This pilot project demonstrates the feasibility of using a simple robotic arm with image processing for tomato harvesting.
* This approach has potential for further development and implementation in digital farming solutions.

A diagram of a computer process

Description automatically generated

A diagram of a robot connection

Description automatically generated