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XXXIV Cycle - II year presentation

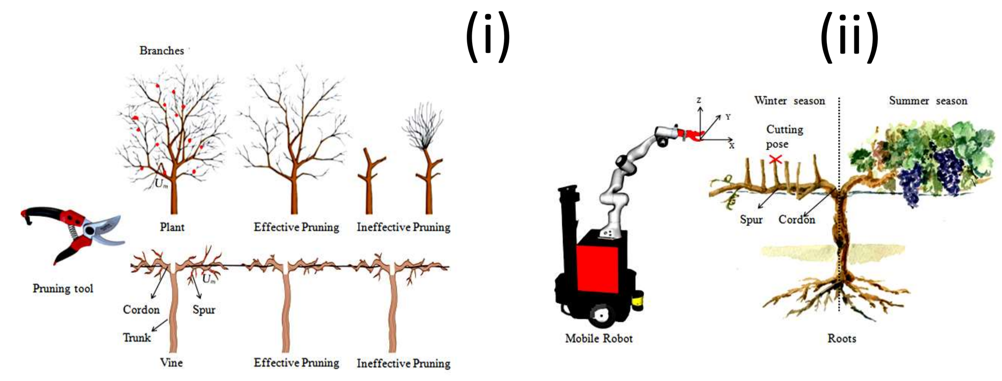
Learning Control For Fine Manipulation Tasks

Main Research Theme

Enabling robots to perform human inspired manipulation tasks do not only necessitate to exploit multi-sensory information but also to match their cognitive and behavioral aspects. Performing fine manipulation tasks, in Figs. (i) and (iii) involve robot hand, in Fig. ii, that is exceedingly complex due to its dynamics and actuation and also the challenges associated with non-prehensile manipulation. A new framework called kernelized synergies has been developed that uses not only visuo-tactile feedback for autonomous object adaptation and interaction but is also capable of initializing the RL loop on learning control policies for complex manipulation tasks incrementally.

(i)

(ii)



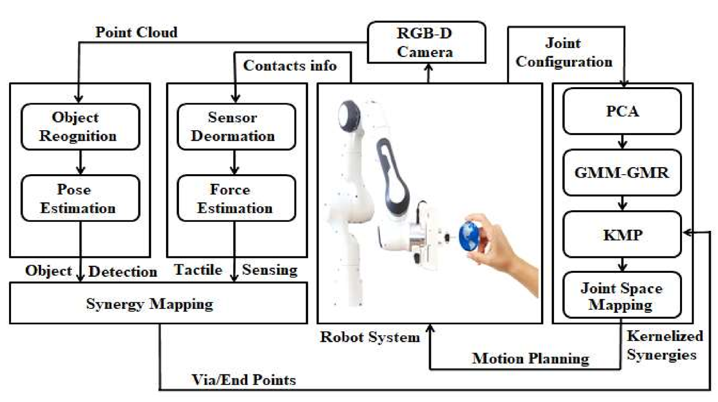
(iii)

Major Activities of Year

The main objectives of the year are to develop kernelized synergies framework and evaluate its performance on different fine manipulation tasks.

Methodology

- Figure shows the block diagram of kernelized synergies framework. With the PCA applied on joint configurations to extract postural synergies which evolve over duration of demonstrations for synergistic trajectories approximated with GMM/GMR for reproducing taught tasks. To deal with new objects i.e. shape and size, the idea of KMP is exploited to deal with via and end points respectively. Such information is updated through visuo-tactile feedback according to the object's dimensions and contact information. The perception pipeline uses RANSAC algorithm together with Euclidean clustering and SVM classifier for semantic segmentation and object detection respectively.

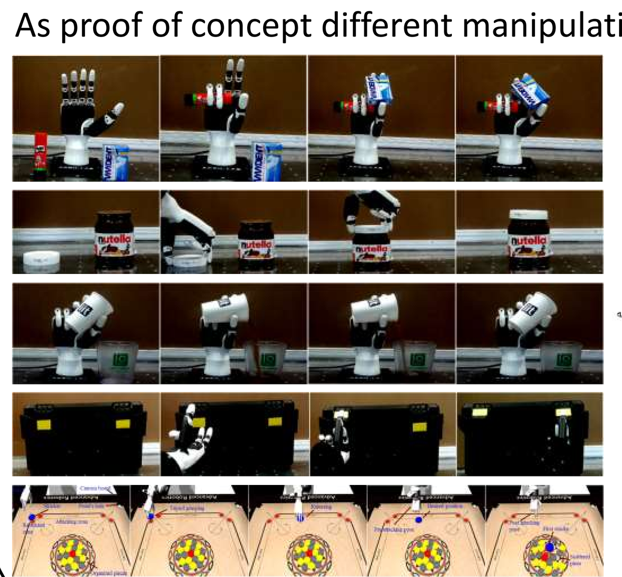


- For tactile sensing, sponge based pressure sensor with 16 measuring points is used for flexible object interactions

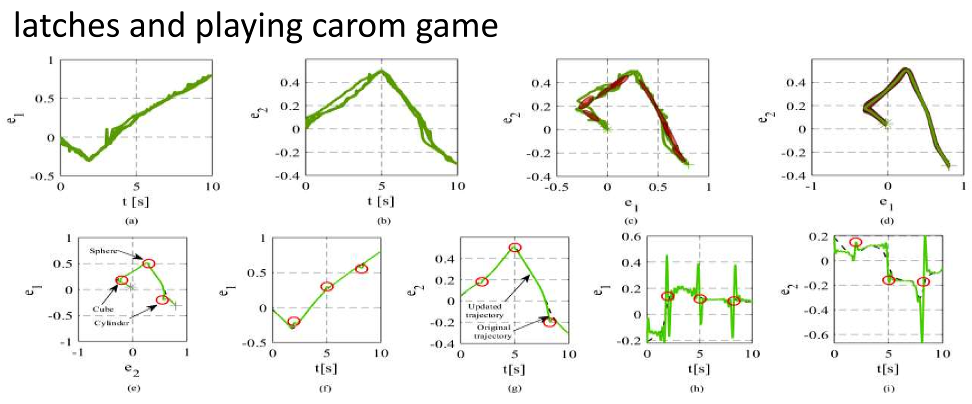
Results-2

As proof of concept different manipulation tasks are performed using kernelized synergies framework

- Kernelized synergistic profile in Fig. (ii) of robot hand grasping and manipulating different objects in Fig. (i) i.e. for dealing with two objects simultaneously, closing jar, pouring coffee, opening latches and playing carom game



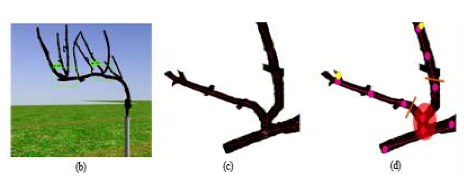
(i)



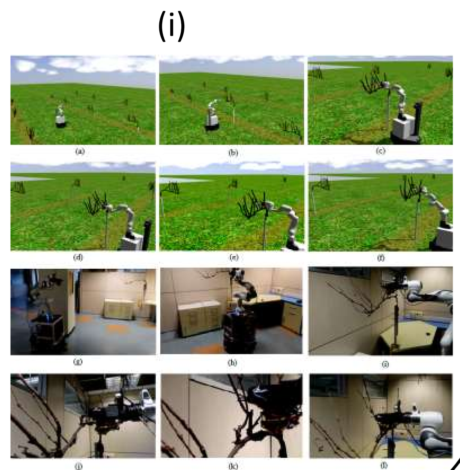
(ii)

Results-1

- The results from spur detection algorithm trained for almost 6 hours are shown in Fig. (i)(b). The bounding boxes represent the possible spurs on the analyzed vine. The graph morphometry of vines using statistical pattern recognition algorithm is shown in Fig. (i)(c).
- The big circle in Fig. (i)(d) on region indicates the classification of spurs, either to prune or not and yellow dots indicate the range of pruning points detected while pink dots denote the effective pruning points to perform required cut.
- With cutting pose shown by orange line in Fig. (i)(d), corresponding synergistic values are computed to plan the motion for robot platform using kernelized synergies framework with its priority characteristics within simulated and real environments as shown in Fig. (ii)



(i)

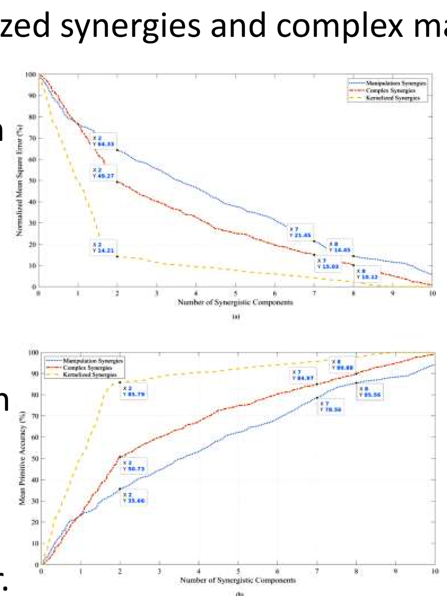


(ii)

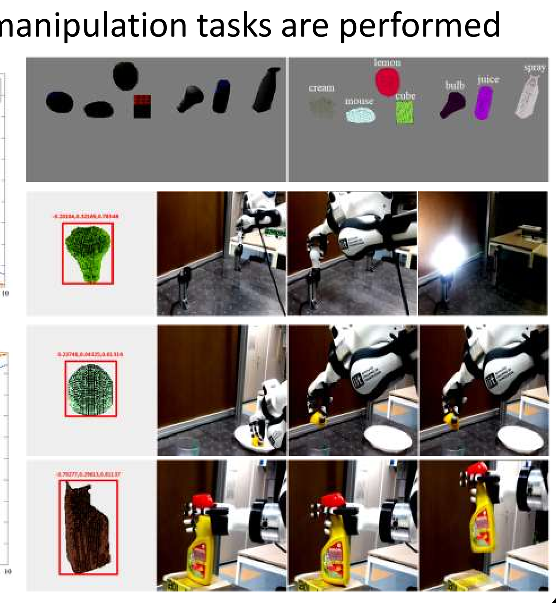
Results-3

Visual sensing is integrated into kernelized synergies and complex manipulation tasks are performed

- Comparative analysis of kernelized synergies framework with manipulation and complex synergies methods using primitive accuracy and normalized squared error is done in Fig. (i)
- The results from perception pipeline on detecting, localizing and estimating pose of objects is shown in Fig. (ii). With the pose of object found, the robot hand grasp and manipulate it autonomously i.e. for mounting bulb, squeezing lemon, and spraying cleanser.



(i)



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Future Developments:

- To do collaborative human-robot manipulation using kernelized synergies, augmented with visuo-tactile feedback.
- To use coefficients of kernelized synergies to initialize the policy of RL algorithm (PI^2) with force/torque profile for solving more complex sequential problems i.e. assembly tasks, mounting tasks, tool use etc incrementally.
- To design 3D models of grapevines, considering their core characteristics i.e. deformability, texture, geometry etc as dataset for deep model training in simulated environments.