

# COORDINATED META-LEVEL CONTROL FOR TRACKING METEOROLOGICAL PHENOMENON

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NetRads [Zink05a, Zink05b]

is a network of adaptive

radars controlled by a collection of

Meteorological Command and Control

(MCC) agents that instruct where to scan

based on emerging weather conditions.

The NetRad radar is designed to quickly

detect low-lying meteorological

phenomena such as tornadoes. Each MCC agent has several radar

associated with it. The MCC agent gathers raw data from the radars and

runs detection algorithms on weather data to recognize significant

meteorological phenomenon [Kra07]. It executes a local combinatorial

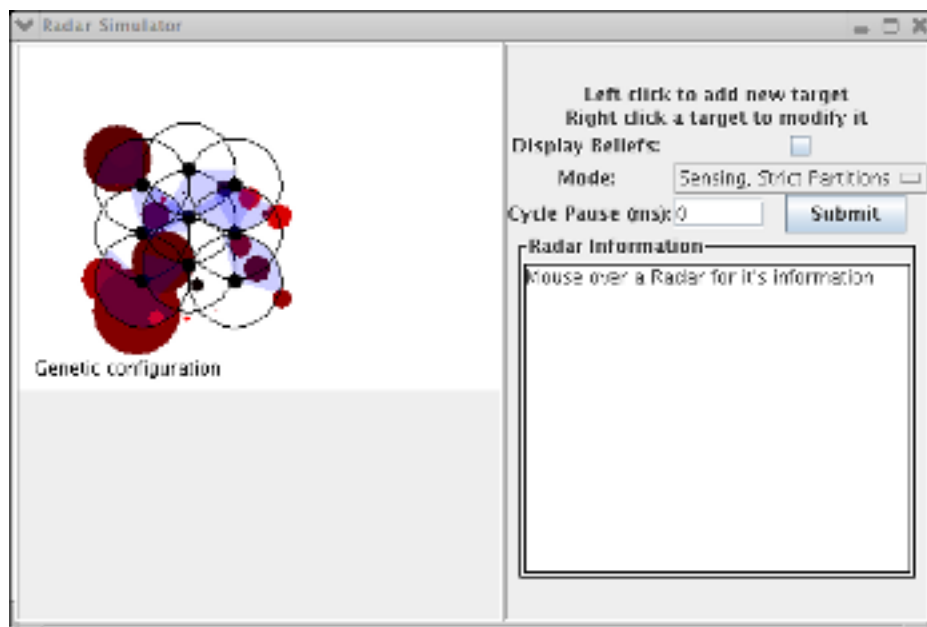


optimization algorithm to determine the best configuration from a local point of view, then exchanges these configurations with neighborhood agents and a hill-climbing negotiation algorithm to determine which radars to activate and how much time to allocate to each task. This process of local optimization and negotiation is time-bounded since radars need to be constantly repositioned to track weather phenomena and recognize the arrival of ones.

Meta-level control in this application will balance the resources spent on local combinatorial optimization versus the number of negotiation cycles. This is important because in certain situations it is better to do a good job in local optimization and allocate fewer cycles to negotiation while in other situations more cycles for negotiation would be better. For example, if there are a lot of boundary tasks, then having more negotiation cycles to coordinate the scanning tasks may be preferable. This work involves gathering data to develop the methodology to determine where this balance is and developing techniques to automate the meta-level control decision making process. The main research questions in developing this methodology as discussed above are:

- How to make meta-level control decisions about deliberations and problem solving contexts?
- Which data to collect for performance profiles?
- How to coordinate the meta-level decision making process among agents?
- How to ensure that meta-level control has low-overhead?
- How to dynamically split the network into sub-networks that are coordinated but do not necessarily have the same meta-level control?
- How to handle multi-agent meta-level control messages?
- How to capture and reason about the sequential nature of these research issues?

In the multi-agent (multi-MCC) context, meta-level control decisions at different agents need to be coordinated [Alex07]. These agents have multiple high-level goals from which to choose, but if two or more radars need to coordinate their actions, the agents' meta-control components must be on the same page. That is, the agents must reason about the same problem and may need to be at the same stage of the problem-solving process (e.g., if one agent decides to devote little time to communication/negotiation before moving to other deliberative decisions while another agent sets aside a large portion of deliberation time for negotiation, the latter agent would waste time trying to negotiate with an unwilling partner). Thus if an agent changes the problem solving context it is focusing on, it must notify other agents with which it may interact. This suggests that the meta-control component of each agent should have a multi-agent policy, where the progression of what deliberations agents do, and when, is choreographed carefully and includes branches to account for what could happen as deliberation (and execution) plays out. We are currently exploring these issues [Cheng10c].



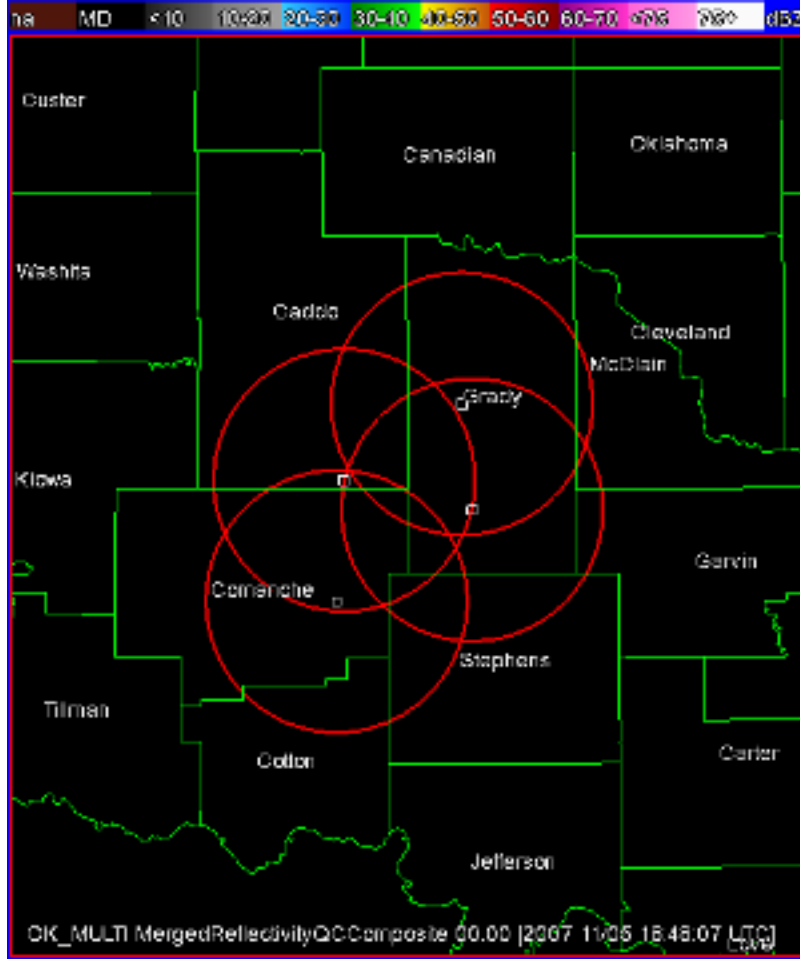


Figure 1: UMASS Netrads simulator to track tornadoes [Kra07]

## OUR APPROACH

We design and develop a multiagent meta-level control (MMLC) approach that involves coordination of decentralized Markov Decision Processes (DEC-MDPs) using the Weighted Policy Learning (WPL) algorithm [Cheng10a].

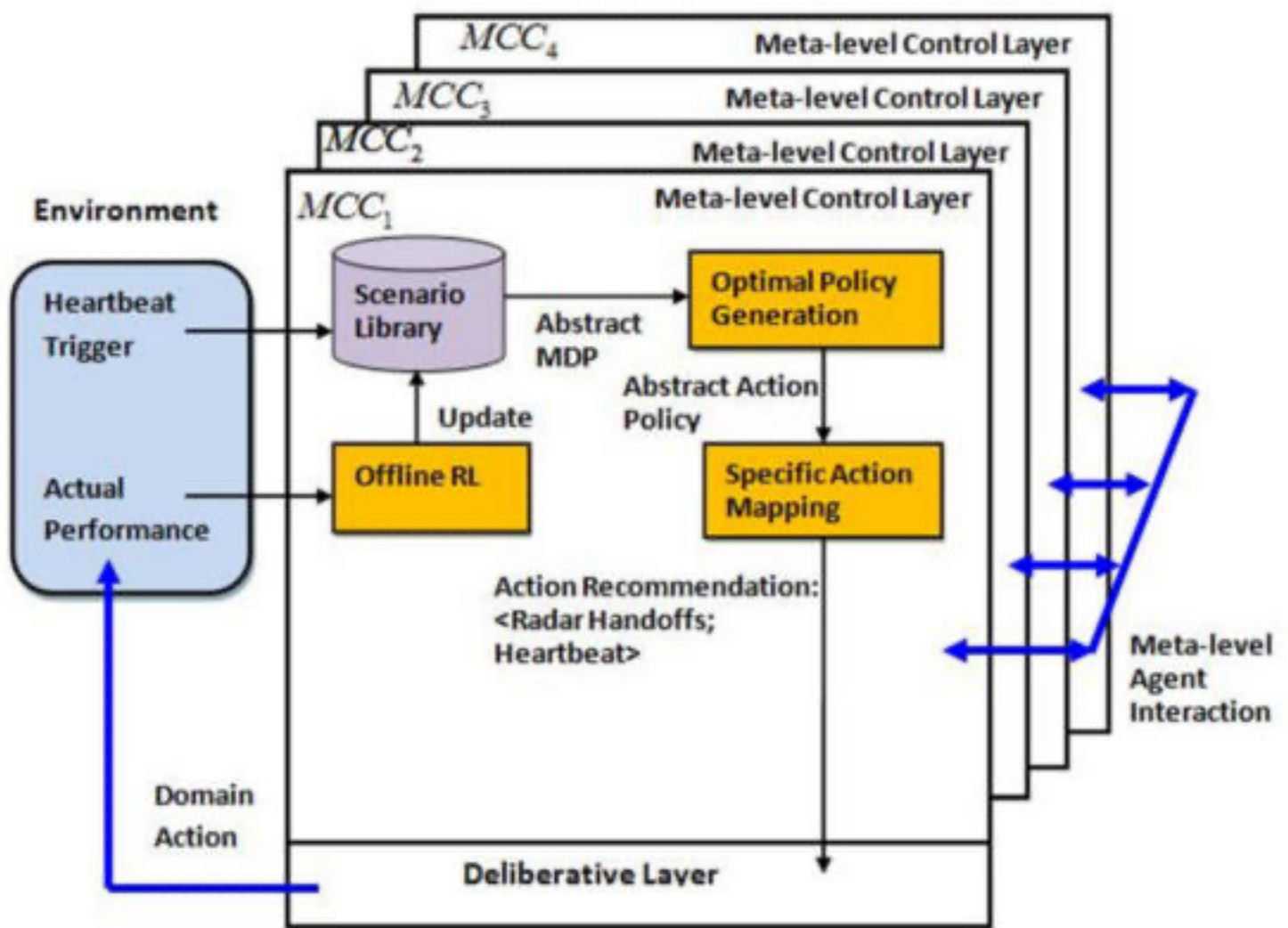


Figure 2: Control flow in MMLC Module of each MCC involving 4 MCCs. [Cheng10b]

## EXPERIMENTS

We empirically show that distributed meta-level control gives a performance advantage in NetRads for a number of scenarios.

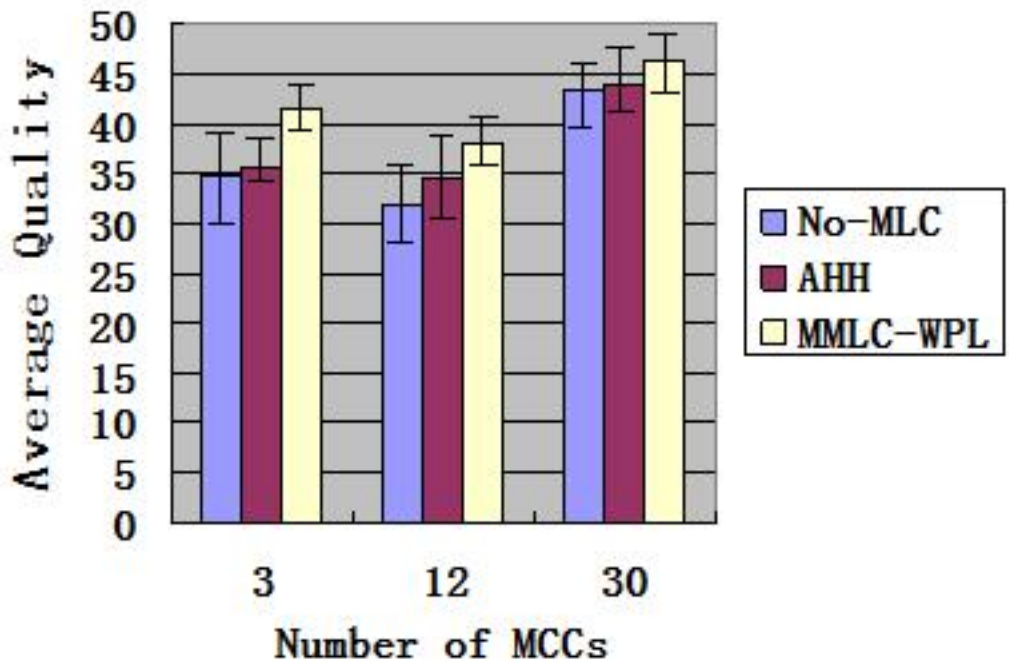
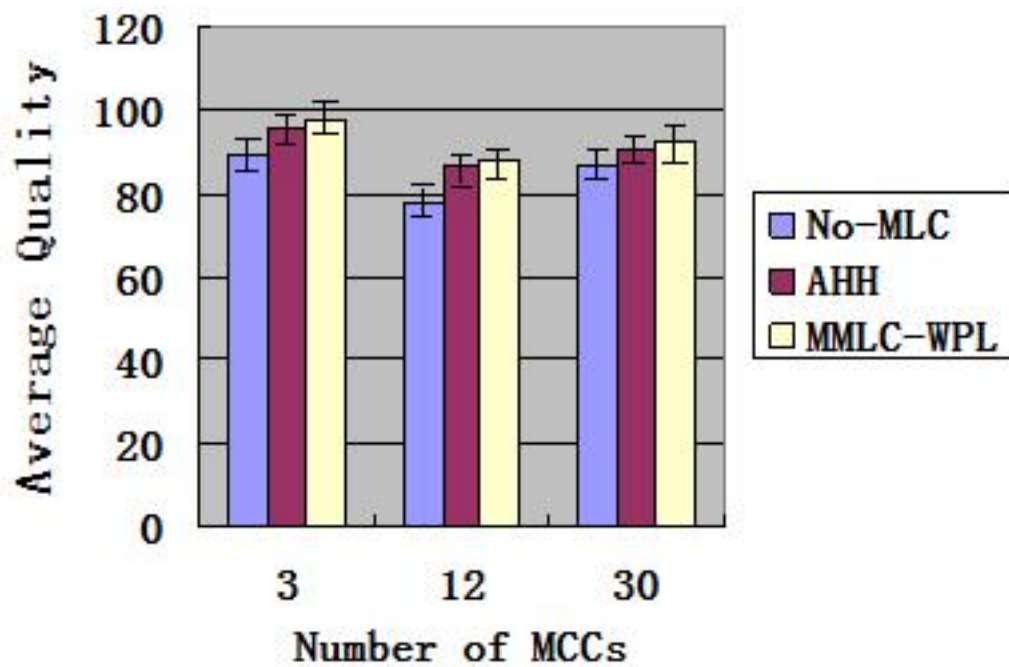


Figure 3: LRHS Scenarios

Figure 4: MRMS Scenarios

[Cheng10a]

[Cheng10a]

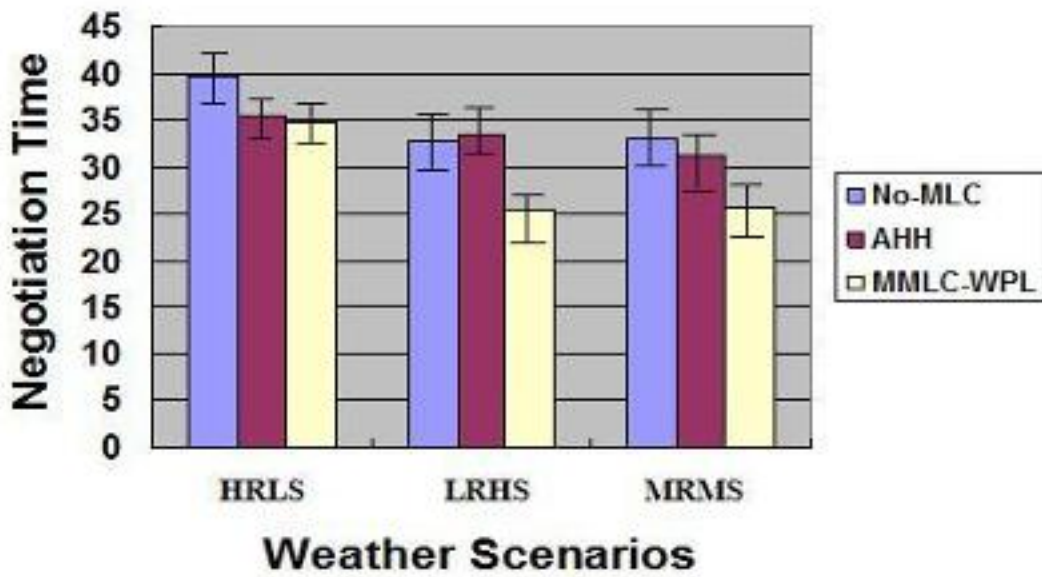
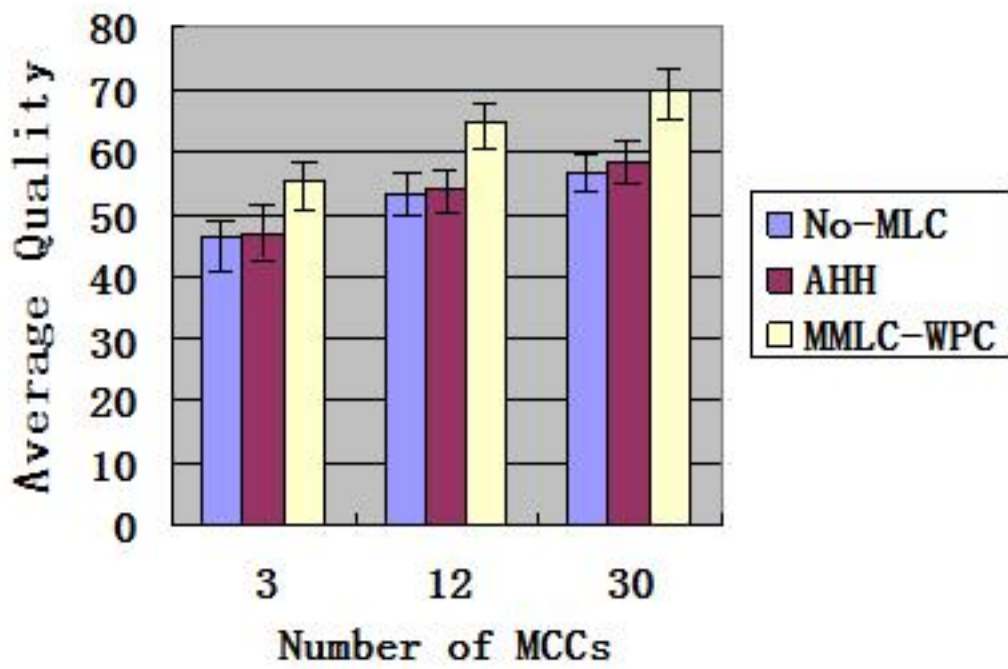


Figure 5: HRLS Scenarios [Cheng10a]

Figure 6: Negotiation Time with 3 MCCs[Cheng10a]

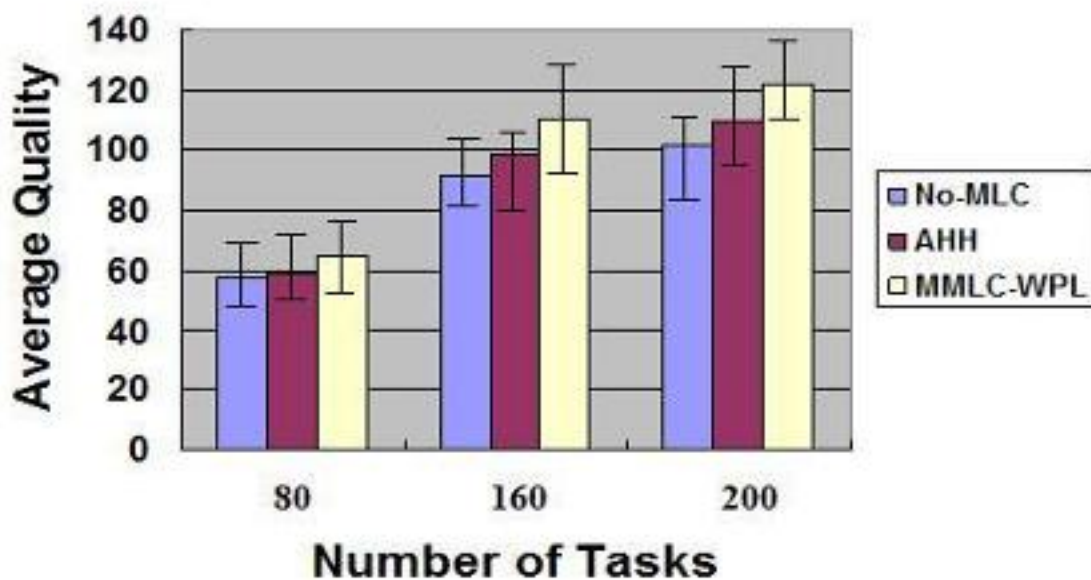
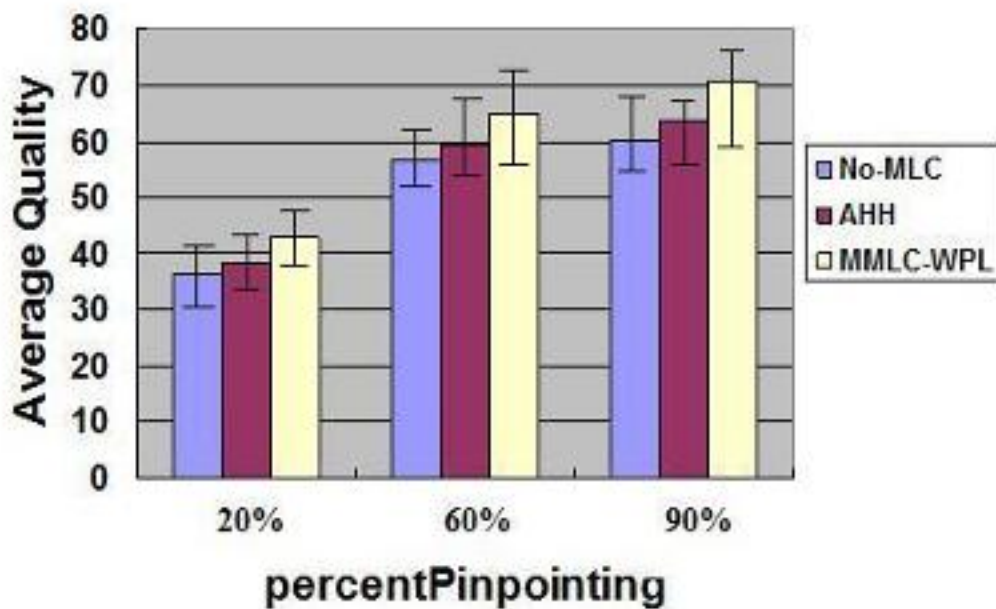


Figure 7: Average Quality wrt percentage of pinpointing tasks

Figure 8: Average Quality wrt number of tasks.

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Images: Courtesy of NOAA and CASA Netrads Simulator

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