Localization using Mobile Wireless Sensor Networks

Course Project - EE 617: Sensors in Instrumentation

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Indian Institute of Technology Bombay

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What are WSNs? What are we doing with WSNs?

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- WSNs for localization, and improving conditions of living for animals and humans at IIT Bombay

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Optimizations $\rightarrow$widespread applications of WSNs

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- Information can be processed using leader-based algorithms or distributed algorithms.

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- No noise or any other interference [4]

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[4] Data are transmitted over an error-free communication channel

Operating Options based on Local Processing and Data Transmission

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- **Distributed Option**: Transmission of a local decision by each sensor node as a binary quantity to the control center [2]
- **Quantized Option**: Transmission of a quantized M-bit quantity after local processing by each sensor node to the control center [3]

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[2] Final decision: based on the K binary quantities

[3] Final decision: based on the K quantized quantities

A Comparison of the Operating Options

The three options are compared based on the probability of error P_e (should be small), the probability of false alert P_f (should be small), and the probability of detection P_d (should be large):

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- Although the centralized scheme uses fewer nodes, the distributed option needs fewer than twice that number to achieve the same detection performance.

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This may cause additional discovery latency since discovery is possible only when neighboring nodes have overlapping active slots.

What is the solution?

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Previous research had introduced the group-based method where a third state for waking up actively is used to communicate the schedule and verify the neighborhood of nodes.

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Niu, Bao, and Xia[5] propose an algorithm that considers the embedded spatial properties and actively modifies the active time of nodes depending on the number of undiscovered neighbors. This has been tested using simulations and the discovery time has been found to be minimal when compared to algorithms presented in existing literature.

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- Indian Institute of Technology Bombay - over 500 acres - home not only to humans but also a wide array of plants and animals from leopards and crocodiles to cows, dogs and cats
- Issues for humans from stray dogs + Issues for dogs from human activities
- What can we do? - track and guide dogs without causing harm to both the human and dog populations

Ideas from Mobile Target Tracking

- Based on mobile target tracking[6], a network of distributed sensors may be placed at suitable locations in the institute.

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- Large size of the campus $\rightarrow$not a scalable solution (number of sensors and energy consumption will be huge)
- The distribution of dogs across the institute need not be uniform $\rightarrow$Placing sensors at certain locations will not be efficient although there is a possibility for a small number of dogs to visit these areas

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Ideas from LMAT

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  - three movable sensors are placed such that the size of their point represents the uncertainty of finding their location.

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Into more details

- Neighbors of a sensor - sensors capable of connecting to and providing information about position and time to the sensor for trilateration at that instant

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- Neighbors of a sensor - sensors capable of connecting to and providing information about position and time to the sensor for trilateration at that instant
- Geometric uncertainty principle - the uncertainty of the location of the sensor increases given the number of neighbors is less than 4 and decreases otherwise
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  $\rightarrow$Similarly, the three sensors in the simulation are constrained within particular regions

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The mechanism is simulated in two-dimensional space within the given dimensions. We initialize the sensors with some positional uncertainty.

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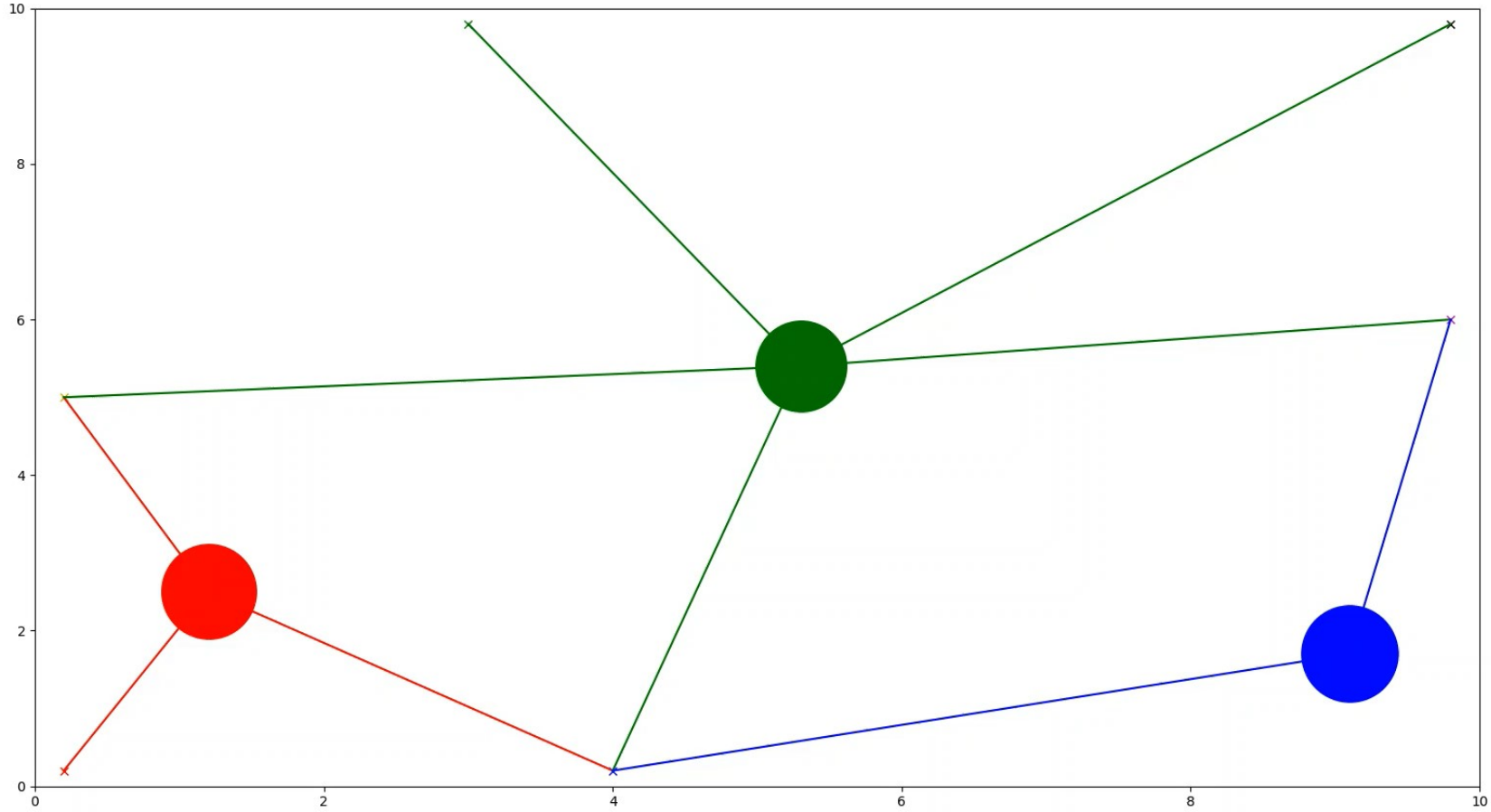

Figure: Initial Configuration - Without Tag Links

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On deactivating links between tags (i.e., they do not behave as mutual anchors), there are larger periods when the number of links is 2 due to which the uncertainty of some sensors is observed to diverge with time.

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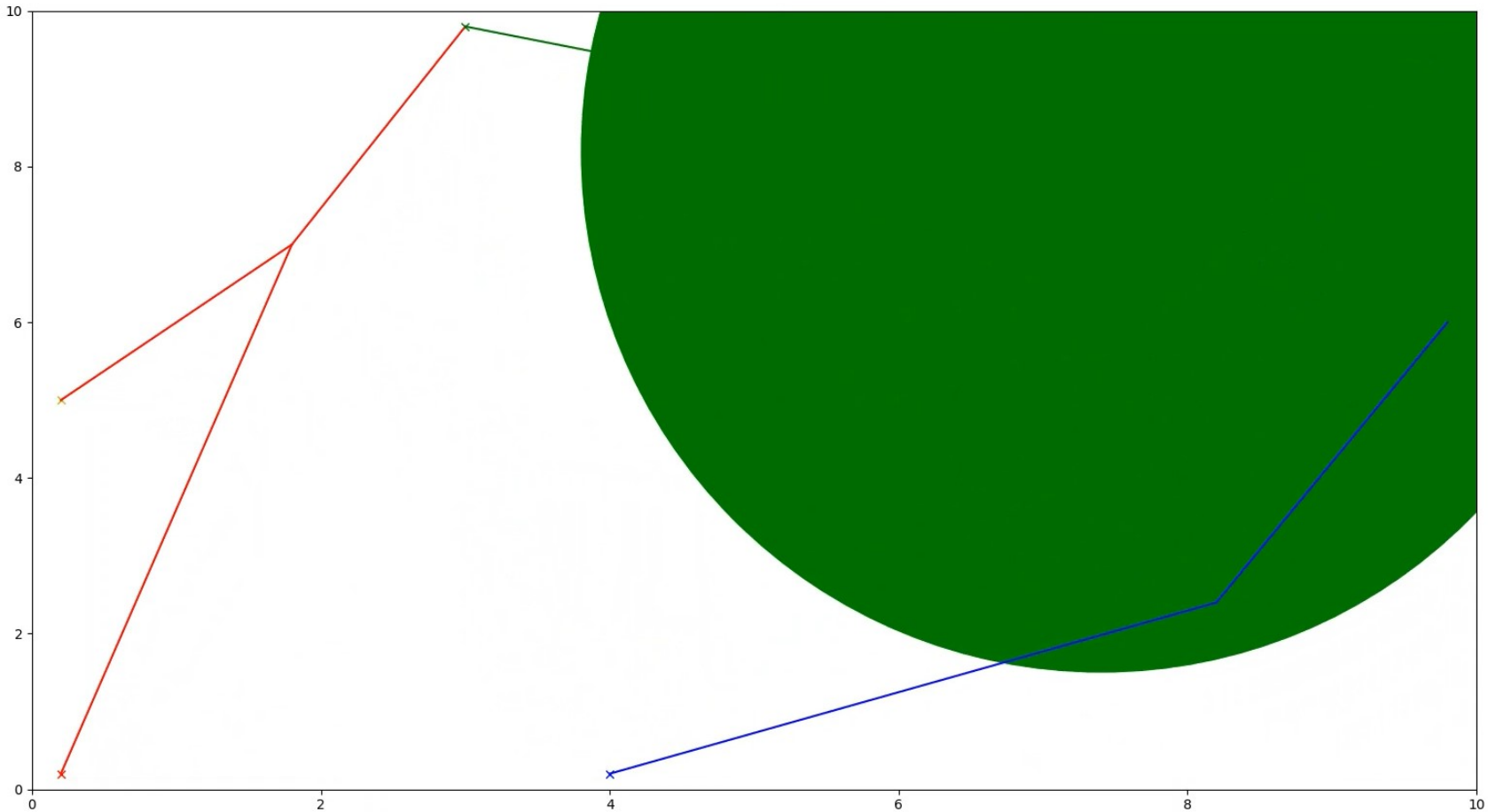

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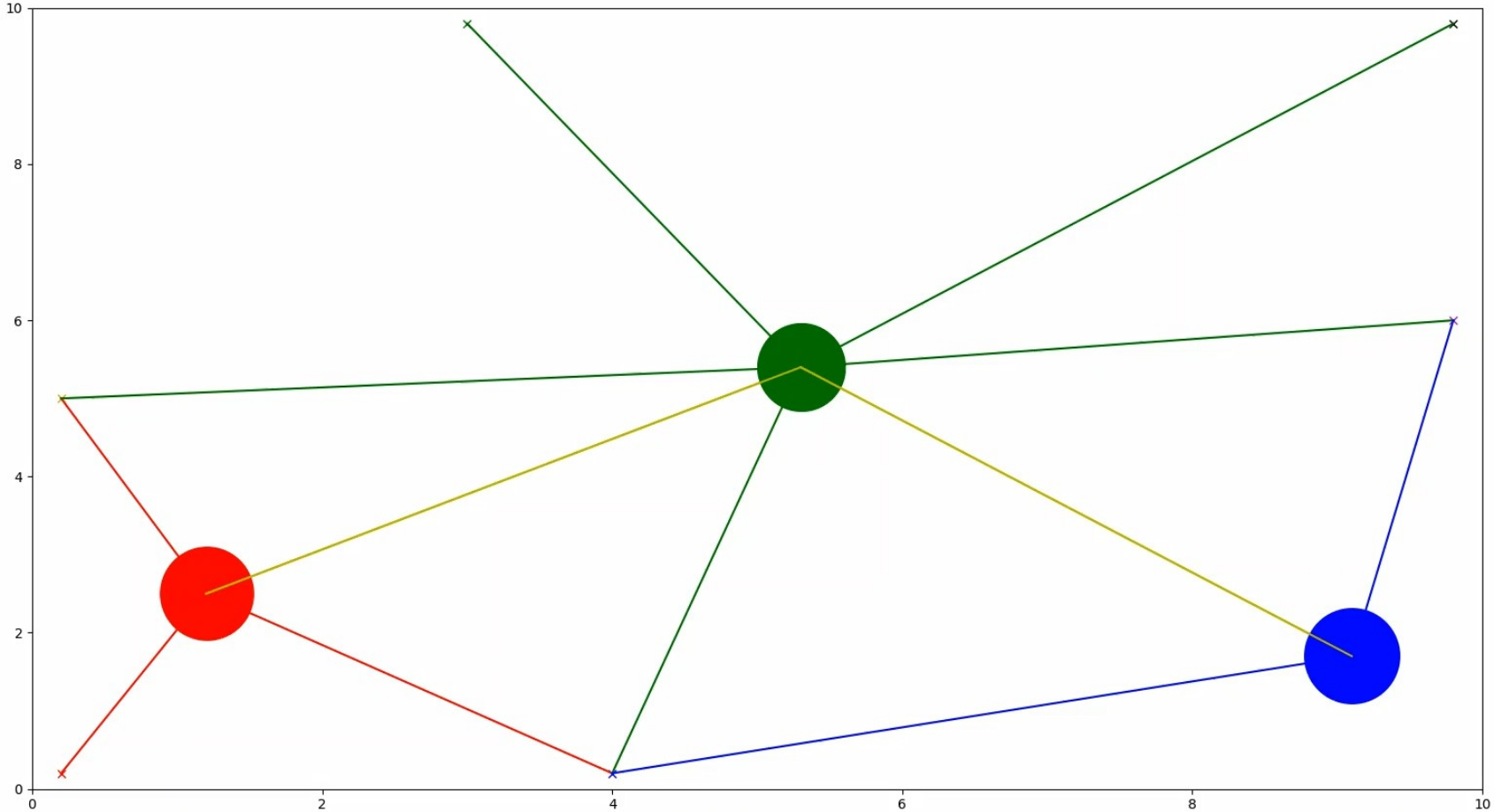

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The uncertainty of the previously mentioned sensors does not diverge since the sensors are in contact with each other for several periods which previously had led to the divergence of uncertainty.

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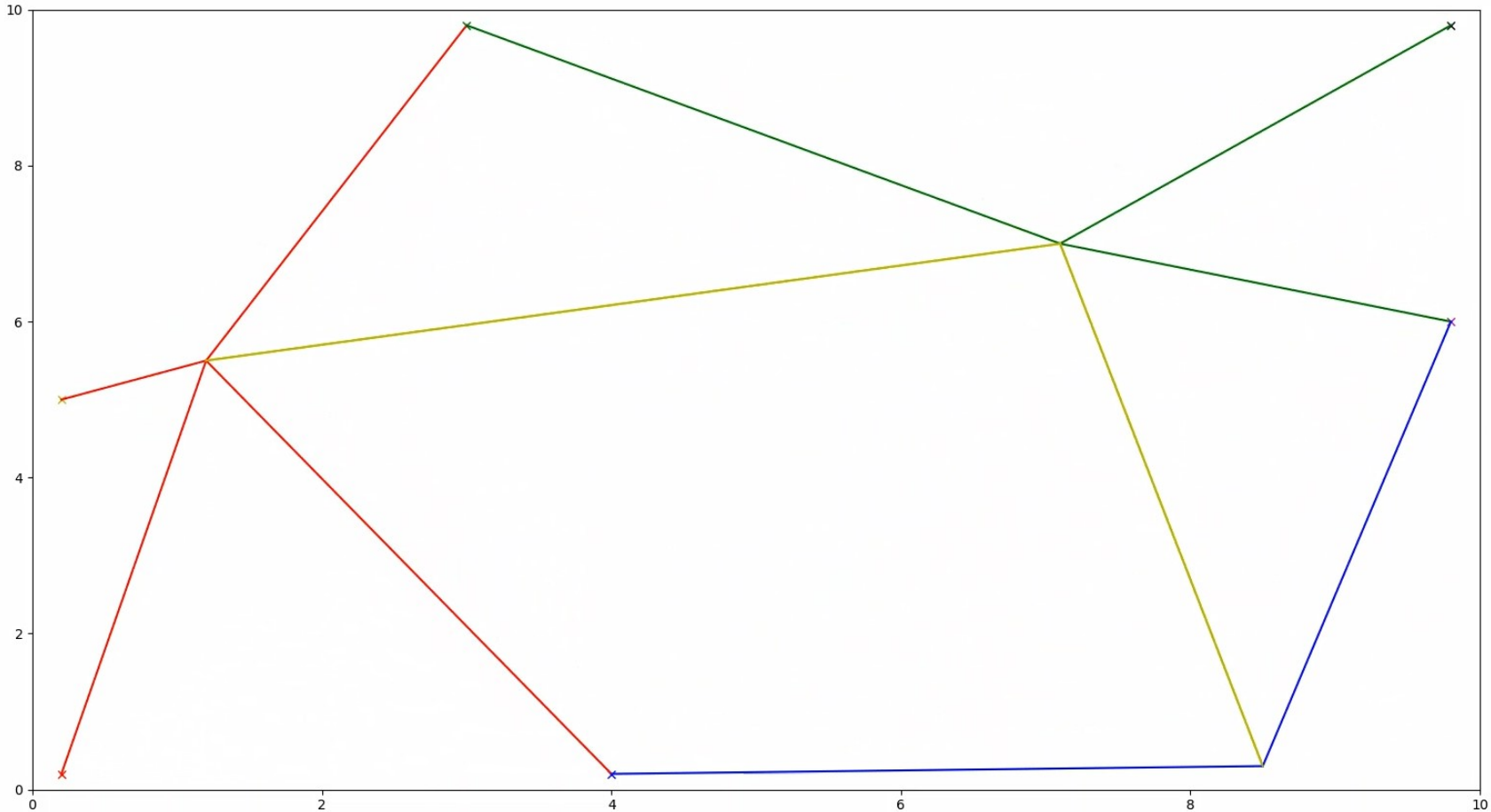

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- Biosensors and flexible electronics may be more appropriate long-term options.
- The long-term effects of biologic cybernetics and electronic stimulation on dogs is open to research although there has been progress in short-duration studies on several animals (Johnson and Fuglevan[9], Rezaee and Kobravi[10], Cao and Doan[11]).

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