NORTHEAST OHIO

PROFESSIONAL ACM CHAPTER

"Advancing the Computing Profession in Northeast Ohio"

2016 CSI CLUE robotics CHALLENGE

DRAFT ANNOUCEMENT REVISION

CSI/CLUE ROBOTICS CHALLENGE

November 2015
June 2016

PART I:

Overview Information

Organizer Name: Northeast Ohio Association Computing Machinery (NEOACM)

Funding Opportunity Title: NEOACM CSI/CLUE Robotics Challenge

Announcement Type: Draft

Dates:

Posting Date: November 1, 2014

Competition Tentative November 2017

Organization Contact

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Concise Description of Challenge

The primary goal of the NEOACM CSI/Clue Robotics Challenge is to develop autonomous robotics systems (non-remote controlled robots) that can work in atleast a 3 agent team in collaboration with a human team to perform forensic analysis in a predefined structured environments. The program will focus on developing practical open source architectural approaches to robotics design and programming. Two approaches will be investigated:

- Behavior-based, bio-inspired approach
- Classic artificial intelligence approach

The goal is to produce a practical hybrid approach to autonomous robotics systems utilizing the best approaches for navigation, vision, reasoning, and sensor/robot control. The program aims to deliver open source architectural software frameworks, libraries, and documentation methods in the follow areas:

- Robot Team Knowledge Representation
- Robot Abductive, Inductive, and Deductive Reasoning
- CSI/CLUE Robotics Challenge Testbed
- Robot-to-Robot-to-Human Communication
- Hybrid Robot Control
- Chemical Forensic Analysis Domain Frameworks
- Robot Environmental Modeling
- Robotic Vision, Pattern and Image Recognition
- Robot System Documentation and UML
- Secure piconets and scatternets for Robot-to-Robot-to-Human Teams

The vehicle of the CSI/CLUE challenge will require a team of robot/agents (atleast 3) to play a modified version of the famous CLUE game within a context of a Crime Scene Investigation (CSI). The team of robots will have to perform chemical analysis in the context of the game, identify the object or article of interest, apprehend the object or article of interest, and transport it to a designated location.

PART II:

Full Text of Announcement

I. CSI/CLUE Robotics Challenge Description

NEOACM in collaboration with:

- Oakhill Robotics Makerspace,
- Youngstown State University,
- Ctest Laboratories,
- Robotteams.org,
- Youngstown/Akron IEEE Chapter,
- IMDS-ASC

is soliciting participation in the NEOACM CSI/CLUE 2015 Robotics Challenge. The challenge will focus on developing hybrid autonomous robot systems (non-remote controlled robots) that can work in atleast a 3 agent team in collaboration with human teams to perform forensic analysis in environments that are challenging, remote or potentially hazardous.

A. Motivation for Forensic Analysis by Autonomous Robotic Teams Collaborating with Humans

In many areas of forensics and forensic science, from chemical analysis, to crime scene investigation, there is a need to gather, collect, protect, transport, and analyze substances and materials in order to make contemporaneous on-the-spot assessments of the status of a scene, scenario, or material. In many situations the forensics, assessment, and analysis need to be made in environments that are challenging. The environment may be remote, obstructed, or otherwise inaccessible to human reach, or may pose a toxic or health risk. The scene may be too large for the available human resources to process in a timely fashion. Handling of substances and materials at the scene may require sensitive movements and precision beyond human capability. An autonomous robot team collaborating with a human team is being considered as a practical part of an overall solution.

B. Program Goals and Objectives

The program will focus on developing practical robotic design and programming techniques for open source architectures by combining behavior-based, bio-inspired robotics with classic artificial intelligence in order to produce practical hybrid autonomous robot systems. The program aims to deliver open source architectural software, frameworks, libraries, and documentation methods in the follow areas:

- Robot Team Knowledge Representation
- Robot Abductive, Inductive, and Deductive Reasoning
- CSI/CLUE Robotics Challenge Testbed
- Robot-to-Robot-to-Human Communication
- Hybrid Robot Control
- Chemical Forensic Analysis Domain Frameworks
- Robot Environmental Modeling
- Robotic Vision, Pattern and Image Recognition
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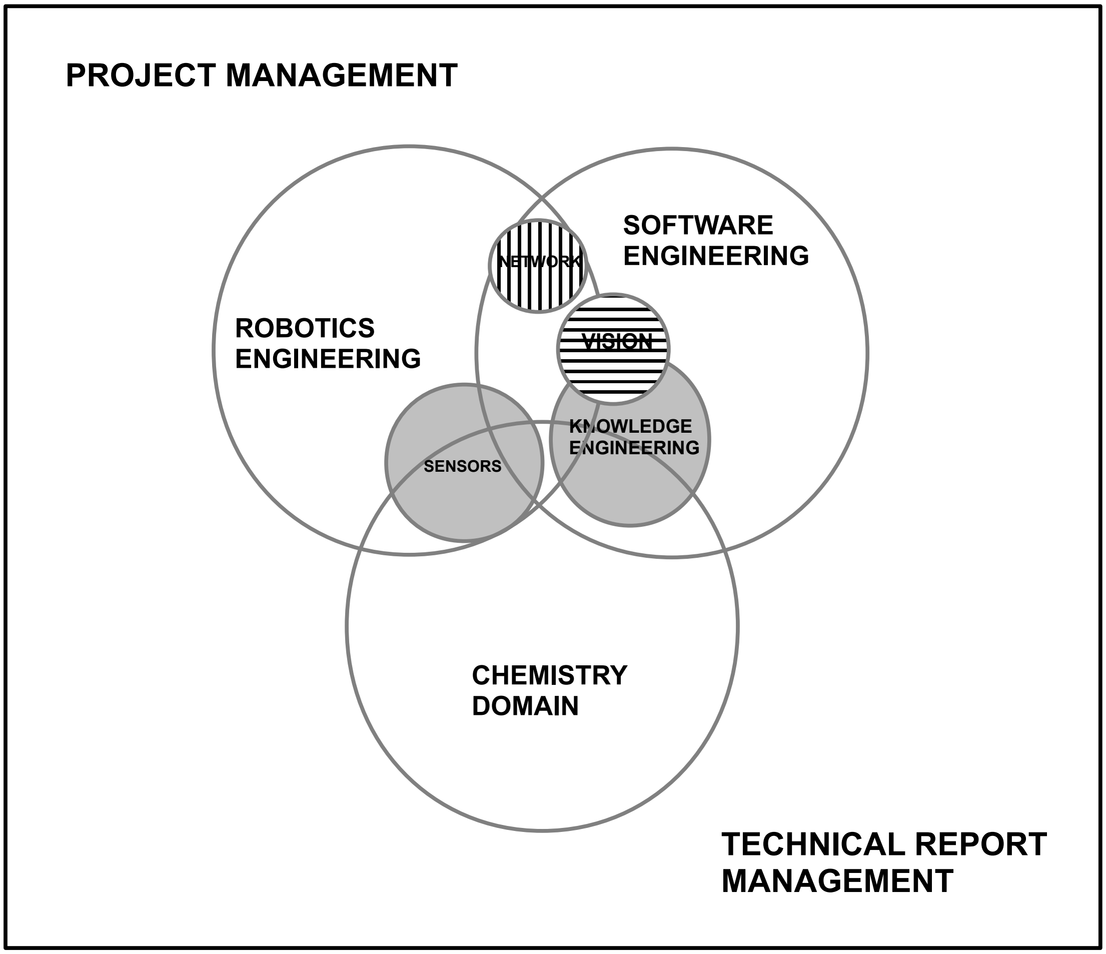
- Secure piconets and scatternets for Robot-to-Robot-to-Human Teams

The program intends to deliver software and hardware artifacts to the robotics development community supporting efforts of the Open Source Robotics Foundation and ROS, LEJOS Robot Framework, and Robot UML.

Below is a VENN diagram of the main of the computer science areas that will be involved in this Challenge.



The program aims to take a cross discipline approach involving Robotics, Engineering, Chemistry, Computer Science, Computational Intelligence, Computer Vision, Wireless Network Communications, Epistemology, and Criminal Justice. The program will foster heterogeneous multi-robotic systems consisting of software agents (residing on connected computers) and physical agents consisting of robots. These multi-robotic systems will be tightly integrated with secure wireless networking that only team members can participate in. We will develop reliable robust secure approaches to social knowledge representation within a team of cooperating robots.

C. Detailed Description

CSI/CLUE Robotics Challenge challenges a set of players consisting of atleast 3 robot/computer team members and one human team member to solve a *who-dun-it* mystery through participating in a “neoquasi” version of the detective game Clue.

Why use CSI/CLUE Scenario?

We selected the Clue game as our vehicle of the challenge for several reasons:

- Clue is a well known game in the U.S
- It requires deductive and abductive inference
- There is a crime scene and evidence component
- There are persons and objects of interest (suspects)
- There is the possibility of reasoning or guessing the wrong conclusion
- It requires navigation and vision

The rules of the game are modified to accommodate robots and time frames. We've also added real substance analysis and other aspects of forensic analysis to game. The scenario game is a hybrid of forensic analysis, crime scene investigation, and the game CLUE. To successfully play the game competing robot teams will be required to perform:

- Vision/object recognition,
- Mobility to navigate known environment that contains an unknown substance,
- Color/object/shape recognition,
- Substance analysis,
- Communication in a secure way with each other using a wireless network,
- Inferential reasoning using a combination of deduction, abduction, and induction,
- Acquisition and transportation of an object of interest to a designated location

In addition to these, the robots must have *'a shared sense of reality'* in order to work together as a team to solve the problem. The robots are working together only within the context of the CSI/CLUE game, but the techniques, architectures, approaches, and schemes employed will be the basis for engineering.

The CSI/CLUE challenge will consist of four major parts:

- Navigation
- Chemical/forensic analysis challenge which will include vision,
- Reasoning that requires deductive and abductive inference,
- Transportation including evidence transport.

The object of the game is to correctly identify, apprehend, and transport individual(s) associated with one or more foreign hazardous chemicals found in a warehouse. The warehouse can store from 3 to 5 chemicals each of which is assigned to a specific location. In the game scenario, all, some, or none of the chemicals are hazardous. No chemicals are identified prior to the game. If a robot patrol unit encounters a container(s) that does not seem to belong in the warehouse, the team must:

(1) Ensure the container(s) are foreign to the warehouse
(2) Determine if the contents of the container is hazardous (using Liquid Chemical Analysis techniques)
(3) If the content of the container is hazardous, the team must determine (using inference):

Who is responsible (associated with the container) based on visual evidence (Geometric and Color) on the label of the container.

(4) Determining who is responsible occurs during the traversal of the game board where the team investigates the suspect(s) and make accusations.

Preliminary Rules:

Rule 1:

The robot traversing the game board cannot be the same robot that has patrolled the Warehouse.

Rule 2:

The robot that patrols the warehouse **cannot** be the same robot that performs the chemical analysis.

Rule 3:
The robot that apprehends the suspect must be different from the robots that traversed gameboard, patrolled the warehouse, or performed the chemical analysis.

Rule 4:
The human member of the team must throw the dice and communicate the throw of the dice to the robot traversing the game board without physically touching the robot.

Rule 5:
The robots cannot be radio-controlled, or otherwise controlled with any type of joystick or hand-held controller (must be wireless). The robot team must be fully autonomous using some form of wireless communication between all team members.

Rule 6:
The robot team must communicate their results also giving its justification :

- why the container was considered foreign,
- why the chemical was considered hazardous
- what was the connection/clue between the suspect and the container
- why that particular connection/clue supported the apprehension of the suspect.

The results must be communicated in natural language easy enough for a spectator or non-technical person (not part of the team in any way) to understand.

Rule 7:
The accusation and the inference must be correct. The accusation can only be done on the appropriate places on the game board to be considered valid. Once an accusation is made, the suspect is removed from the suspect area and placed in the holding area/penalty box.

Rule 8:
The suspect must be transported to the penalty box without being damaged. The contents of the container must be analyzed without being spilled and the container cannot be damaged.

Rule 9:
Once the accusation is made, this is the end of the game.

<u>Facts about the Game Area, and Components:</u>

The Game Area will consist of at least four major components:

- The Warehouse
- The Gameboard
- The Penalty Box
- 3 to 5 Beakers containing unknown liquids with associated visual clues

<u>Clues</u>

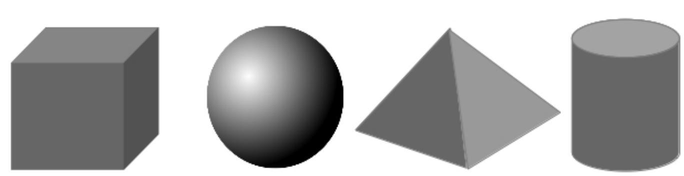
Clues will be given prior to the game. Further, there will be a color relationship between the foreign container and the suspect (e.g. the container has a orange marking and the suspect has a red and yellow marking). The robot must be able to infer the
the color relationship (red + yellow = orange) based on the color facts that will be given prior to the game.

There may be more than one correct set of inferences that can be drawn from the geometric shapes and colors between the suspects and the containers, and many incorrect inferences that can be drawn.

<u>The Suspects</u>

There will be **4 possible** suspects which will weigh no more than 1lb. For example:

- cube,
- sphere,
- pyramid
- cylinder



The suspects will not all have the
same shape. Each suspect will be labeled. The suspects and labels will be examined by

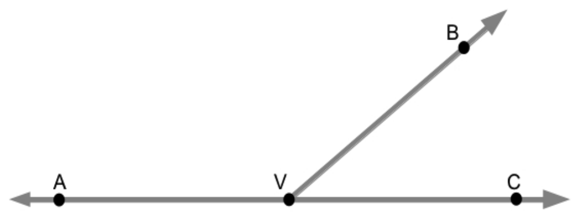
the robot prior to gameplay.

Definitions For Inferencing Suspect Associations

The containers' CLUE used to infer an association with the suspect will be based on these definitions:

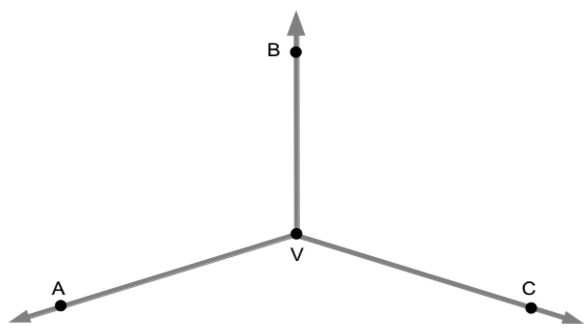
A ***LINEAR PAIR*** of angles is a special case of a pair of coplanar angles.

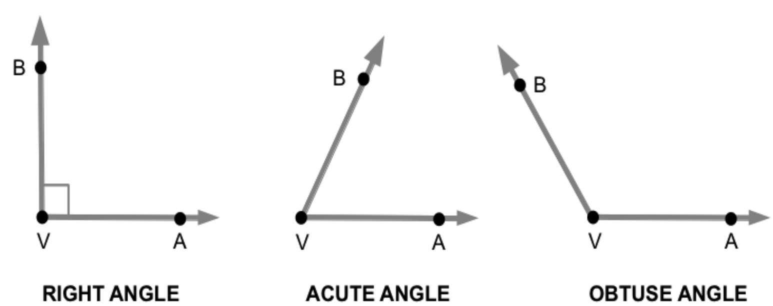
Angle AVB + Angle BVC = 180



Definition 1 Two coplanar angles are *ADAJACENT ANGLES* if they have one side in Common and the intersection of their interiors is empty.

Angle AVB and Angle BVC are ***ADJACENT ANGLES***



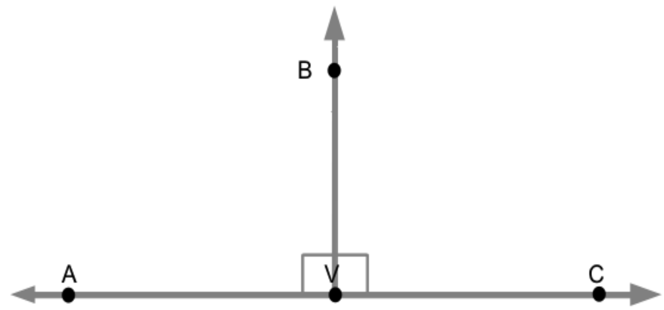


Definition 2 An angle whose whose measure is 90 is a RIGHT ANGLE.
An angle whose measure is less than 90 is an ACUTE ANGLE.
An angle whose measure is greater than 90 is an OBTUSE ANGLE.

Angle AVB as RIGHT, ACUTE, and OBTUSE Angles.

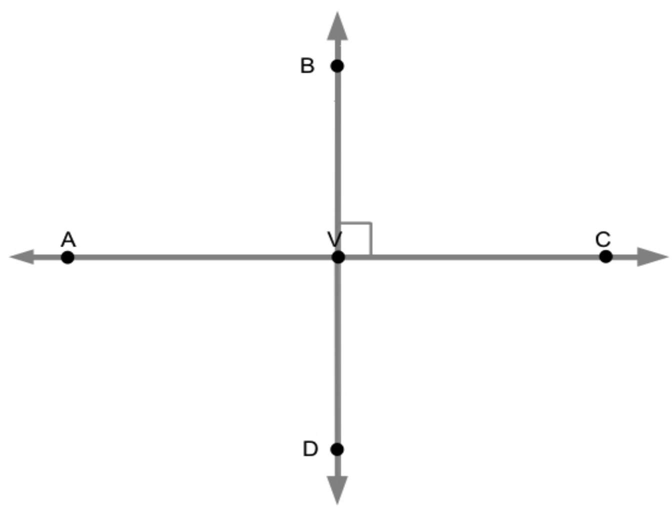
Definition 3 Any two right angles are congruent. Every right angle has a measure of 90. Hence all right angles have the same measure and hence all right angles are congruent to each other.

Angle AVB   *AngleBVC*



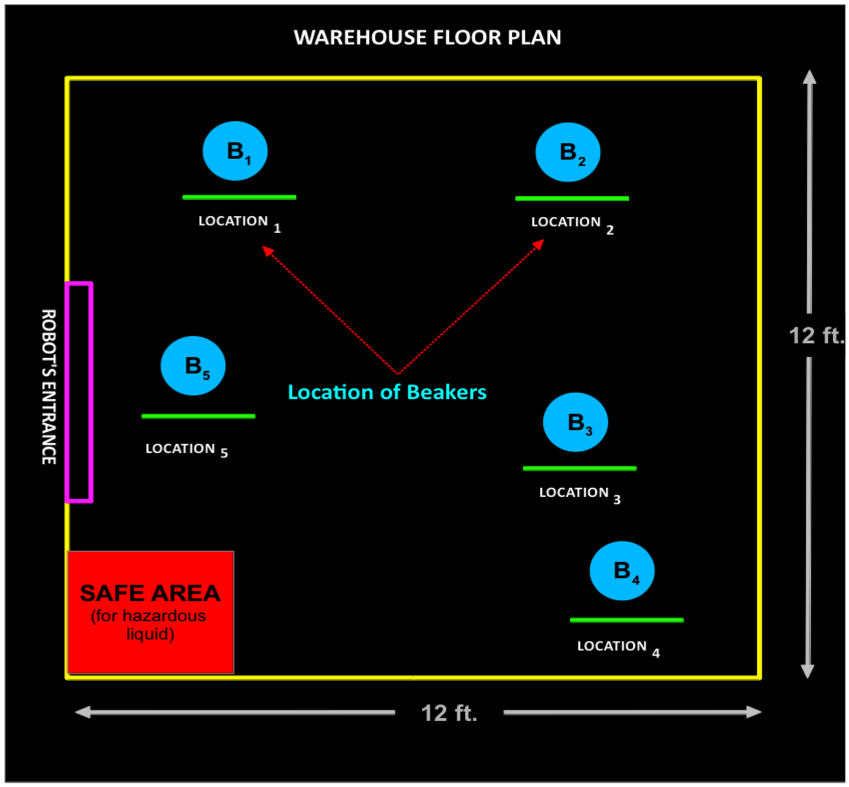
Definition 4 If the union of two intersecting lines contains a right angle, then the lines are PERPENDICULAR LINES.

*If Angle BVC is a **RIGHT ANGLE** , then Line AC and Line BD are **PERPENDICULAR LINES**.*



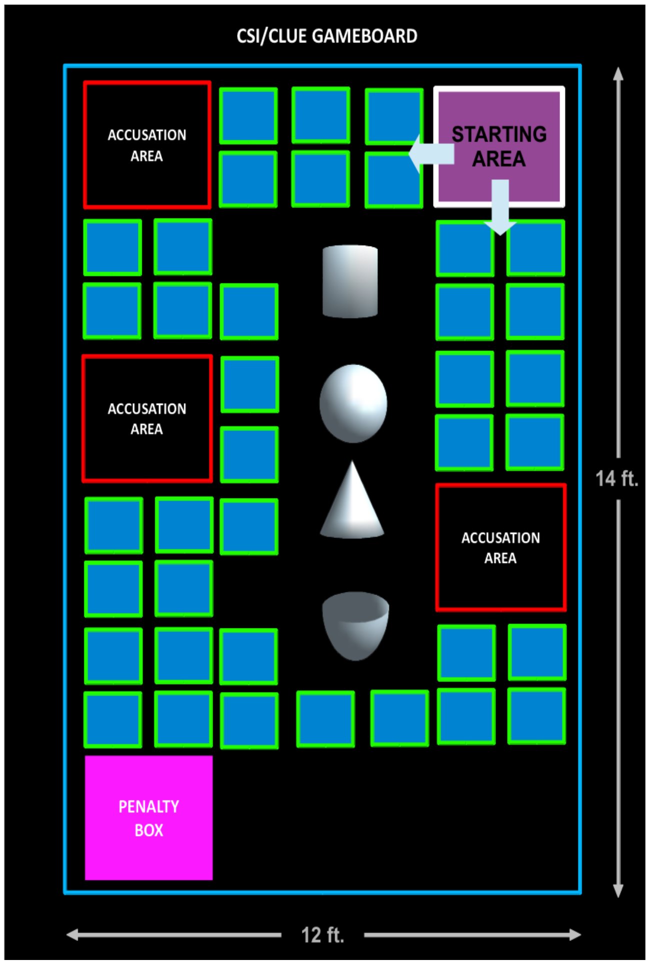
Warehouse Floor Plan

Warehouse will contain 3 to 5 containers (beakers). Each Beaker belongs in a specific location identified by either RFID or BarCode. Each Beaker will contain an unknown liquid.



Gameboard

Here are the logical components of gameboard (not to scale of physical count of positions).



ROBOT AND GAMEBOARD/WAREHOUSE MATRIX

COMPONENT	DESCRIPTION	Capability	DIMENSION/ FOOTPRINT
Warehouse	Contains the containers of liquids to be identified by the robot. The Scout Bot investigates the locations of all containers. If a container is out of place or a new container is located, the chemical substance is identified and determined if it is hazardous by the ChemBot. The container containing the hazardous is then removed by the ChemBot.	Contains: 4-5 containers that contain hazardous or non-hazardous liquids. 4-5 designated locations for containers 1 container out of place or an unknown additional container containing a liquid	12ft. x 12ft.
Gameboard	Gamebot navigates the gameboard in order to make its accusation. Each accusation area is a body of water that has been contaminated by a chemical from the warehouse. The label is a clue that associates that chemical with one of the suspects. Gamebot must use the clue and associate it with the clue on the suspect and make an accusation once in the accusation area (body of water). That is the suspect that contaminated the body of water.	**Suspect Area:** Gamebot examines each suspect in the area by examining its label. **Gameboard spaces:** Gamebot navigates the board by moving the number of spaces based on the roll of the dice by the human team member. **Penalty box:** Suspect once accused is placed in the penalty box by ChemBot or Relocator Bot.	12 ft. x 14 ft.
ChemBot	Performs analysis on liquid in container once identified by Scout Bot. If liquid is hazardous it must relocate container to a safe location in the warehouse.	**For Analysis:** Color Sensor pH Sensor **For Navigation:** Range Finder Compass, Vision sensor **For Mobility:** Wheels **For Object Manipulation:** Arm with appropriate end-effector **For Communication:** Bluetooth/WiFi	40 cm x 36 cm

Scout Bot	Navigates the warehouse to investigate each known location of the container. Locates containers out of place or unknown containers. Communicates location of unknown or out of place container to ChemBot.	**For Navigation:** Range Finder Compass, Vision sensor **For Object & Pattern Recognition:** Vision sensor Color sensor **For Mobility:** Wheels **For Communication:** Bluetooth/WiFi	26 cm x 30 cm
GameBot	Navigates the gameboard. Examines all the suspect's label while suspect is in the "suspect area". Determines the suspect connected to the hazardous liquid based on the clues on the labels. Makes as accusation once in an accusation area. Communicates to ChemBot/Relocator to remove the suspect and place it in the penalty box.	**For Navigation:** Compass, Color, **For Object & Pattern Recognition:** Vision sensor Color sensor **For Mobility:** Wheels **For Communication:** Bluetooth/WiFi	26 cm x 30 cm
Relocator	Used to relocate the suspect from the "Suspect Area" to the "Penalty Box".	**For Navigation:** Range Finder Compass, Vision sensor **For Mobility:** Wheels **For Object Manipulation:** Arm with appropriate end-effector **For Communication:** Bluetooth/WiFi	40 cm x 36 cm

<u>CONCEPTS OF THE CSI/CLUE ROBOTICS CHALLENGE</u>

Basic Clue Game

The object of the game is to determine who murdered the game's victim, where the crime took place, and which weapon was used. Each player assumes the role of one of the six suspects, and attempts to deduce the correct answer by strategically moving around a game board representing the rooms of a mansion and collecting clues about the circumstances of the murder from the other players. At the beginning of play, three cards — one suspect, one weapon, and one room card — are chosen at random and put into a special envelope, so that no one can see them. These cards represent the facts of the case. The remainder of the cards are distributed among the players. All players roll the dice and the highest total starts the game and then proceeds clockwise. Players roll the dice and move along the board's corridor spaces, or into the rooms accordingly.

The aim is to deduce the details of the murder; that is, the cards in the envelope. There are six characters, six murder weapons and nine rooms, leaving the players with 324 possibilities. While determining the details of the murder, players announce suggestions to the other players. To make a suggestion, the player's token must be in the room they suggest; suggestions may not be made in the corridors. The token and weapon suggested are moved into the room, if not already present.

Other players of the game must then disprove the suggestion, if they can, by showing the suggesting player one (and only one) of the cards containing one of the suggestion components (either the suspect, the weapon, or the room), as this proves that the card cannot be in the envelope. The suggesting player's turn then ends. The suggesting player does not advise the other players whether they hold any of the three cards. Once a player has sufficiently narrowed the solution, that player can make an accusation. According to the rules, "When you think you have worked out which three cards are in the envelope, you may, on your turn, make an Accusation and name any three elements you want."

The Challenge: Bio-Inspired vs. Classic GOFAIR (Good-Old-Fashioned-AI- and-Robotics)

Which approach (Bio-inspired vs. Classic GOFAIR) to robot design, implementation, and programming from human and robot perspective is best suited for:

Investigating and solving mysteries where only limited physical evidence is available.

Needed for the Challenge:

A Team of Robots that can investigate a scene that contains a mystery for the team of robots to solve. The team must solve the mystery, report the solution and justification for the solution, and take whatever allowable and appropriate action that the solution infers.

The team of robots have to be able to:
collect, *protect*, analyze & interpret physical evidence, using chemical analysis. Must be able to perform deduction, *and reason about geometric shapes and color analysis*.

The team of robots is doing work typically done by:

- Evidence Recovery Technician
- Forensic Scientist
- Crime Scene Investigator
- Detective

The CSI/CLUE Robot Investigation is a systematic attempt at using abduction, induction, and deduction to learn the facts about an association that is hidden, complex or otherwise mysterious and then take allowable and appropriate action based on what is learned.

A Short History of the CSI/CLUE Robotics Challenge

By Cameron Hughes

It was one of those weird intersections where a few people who wear several hats get together for a book project. Roger Stewart, one of the editors of at McGraw Hill, thought we should write an introductory book on robotics. Three guys and a gal with multiple things and organizations in common, Trevor Watkins, Robert Kramer, Tracey Hughes and myself, were all ACM members, graduates and or professors at Youngstown State University, and all with interests in robotics. Trevor, Tracey and myself had the additional intersection of all being researchers at small non-profit research group at Ctest Laboratories. The book project was the initial context for the CSI/CLUE robotics challenge and its contents, goals, objectives. The current form of the CSI/CLUE challenge was influenced by a core group of members of the Northeast Ohio ACM Professional Chapter: Andrae Reed, John Dalbec, Bonita Sharif, Steve Taraszewski, Robert Gilliand, all who work or teach at Youngstown State University. In addition to the NEOACM/YSU influence, many of the core reasoning and knowledge representation challenges were strongly influenced by research at Ctest Labs in computational epistemology. These influences were all heaped on a simple introductory robot program that started in, and grew out of our McGraw Hill book project. The program requirements were simple:

Coordinate *a team of robots to patrol a small warehouse area, take account of what should be there, report any anomalies, and take any action required that is part of the robot's programming.*

This is an over simplification of the project described in Chapter 11 “The CSI Project”, one of the chapters we were responsible to write. Because of our research at Ctest Labs, the little robot project was similar to agent-oriented approach and other areas in Artificial Intelligence.

This was the beginning of the NEOACM CSI/CLUE Challenge that started to come together in 2013. In September 2013, the NEOACM Chapter sponsored a screening of the Alan Turing film “Codebreaker” ,hosted by Patrick Sammon, creator and the executive producer. The event was both a great success and well attended by students, faculty and members of the community. At the followup meeting, we were trying to figure out what the next big project for the NEOACM Professional Chapter. I suggested a collaboration with Youngstown State University and Ctest labs to hold and promote the CSI/CLUE Robot Challenge. There was talk about starting a robotics lab in the computer science department, even possibly offering a course to support the effort. Robert Kramer, Bonita Sharif, and Robert Gilliand all teach in the Computer Science and Information Systems Department, so voila we had the germ of a plan for how we might get some participants for the challenge. All that was needed was the formalization of the challenge! The CSI/CLUE Robotics Challenge would undergo considerable discussion, debate, and refinement in 2014- 2015 at the hands of many other contributors. But we'll save that history for the next Robotic’s Challenge. Stay Tuned!