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# The 1994 AAAI Robot-Building Laboratory

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■ The 1994 AAAI Robot-Building Laboratory (RBL-94) was held during the Twelfth National Conference on Artificial Intelligence. The primary goal of RBL-94 was to provide those with little or no robotics experience the opportunity to acquire practical experience in a few days. Thirty persons, with backgrounds ranging from university professors to practitioners from industry, participated in the three-part lab.

The 1994 AAAI Robot-Building Laboratory (RBL-94), held during the Twelfth Annual Conference on Artificial Intelligence (AAAI-94), was the second robot-building event offered at the national AI conference. The event was meant to appeal to the hacker yearnings of participants to experience for themselves the joys and excitement of constructing a robot and to learn about the real problems of such an endeavor. RBL-94 was inspired by and shared a common history with a couple of robot-building laboratories. In tracing the roots of RBL-94, one has to go back to the electrical engineering 6.270 course offered by the Massachusetts Institute of Technology (MIT).[1] The 6.270 course is financially supported by MIT and outside sponsors. It is a student-organized event held every year in January. A tradition of the event is that 6.270 participants, or graduates from previous years, become organizers for the next year.

Some of these organizers have recently decided to make the technology developed for the 6.270 courses available to a wider audience. In particular, Pankaj Oberoi founded 6.270 Technologies, which sells the robot kits, and Randy Sargent and Anne Wright develop and market INTERACTIVE C (IC). Several generations of 6.270 organizers contributed to the documentation.[2]

Sometime around 1992, David Miller and Lynn Stein, both at MIT at the time, decided to organize the first robot-building laboratory (RBL-93) at AAAI-93 in Washington, D.C. (Kadie 1993). They recruited several 6.270 organizers to prepare all the materials, manage and supervise the lab, and provide teaching assistance. Funding from the American Association for Artificial Intelligence (AAAI) and other agencies made it possible. The fee for participating in RBL-93 was low, but all participants were required to take the Mobile Robots I Tutorial given by David Miller and Mark Slack. About 70 people signed up for RBL-93. The more than 20 teams created a lot of activity and excitement in a small designated area right next to the exhibition and the big robot competition. The contests generated a lot of excitement and enthusiasm among both the participants and the audience. There were many requests for further information and some expression of disappointment from other AAAI-93 visitors about having missed the chance to participate. This enthusiasm and some ongoing discussions on a mailing list for RBL-93 led to the formation of an RBL-94 committee composed of RBL-93 participants. Proposals were written, budgets defined, technology issues discussed, and contest ideas evaluated. With a lot of help from AAAI, RBL-94 finally happened.

## The Spirit and Objectives of RBL-94

Robotics on the small scale draws interest toward simple systems and tasks that can be accomplished with low-cost technology. A robot-building laboratory can encourage participants to consider ways of achieving complex behavior from simpler, more available technology, leading to faster commercialization and increased demand in the robotics market. Even though the technology on which the robot-building–lab hardware and software is based is not new, using it to construct a working robot requires one to deal

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with the problems and complexities of system integration. Although some of the integration problems are mechanical in nature (for example, affixing a sensor to the mobile base such that it cannot fall off), most must be solved in software. Thus, building good robust software is the key to integration.

Another lab objective is to expose theorists to real-world problems that require real-world solutions. In the specialized disciplines of AI, it is easy to lose sight of the big picture, that is, what problem solving in the real world is about. Often, important aspects of real-world problems are abstracted away, simplified, misrepresented, or even misunderstood, leading to solutions that have little or no practical use. Such an exposure to reality might not necessarily change one's research priorities, but it will at least lead one to appreciate the issues that arise in such experimental, empirical work. Our belief is that RBL is good for theorists. Practitioners also benefit. Just focusing on the hardware construction without equal attention being paid to the software will not be fruitful. Practitioners need a powerful, expressive control architecture that is easy to understand and implement. The theoretical work on agent architectures and their formal underpinnings can provide important insights in this area.

Another objective of a robot-building lab is to encourage teamwork. Blending the different backgrounds and skills of the team members (and their different personalities) into a collaborative group is a challenge in itself. There is a lot of fun and excitement during the lab, but long hours and frustrations are also unavoidable at times. The competitive spirit that naturally develops among teams competing in robot-building contests helps teams to focus and work cooperatively. With the teams working close to each other and, hence, being able to see what each other is doing, free exchange of ideas across teams results. This cooperation leads to better robot designs overall as good ideas are shared. One of the goals of RBL-94 was to promote a blend of cooperative and competitive spirits among everyone involved—participants, teams, teaching assistants, and organizers.

## The RBL-94 Event

The primary goal of RBL-94 was to provide those with little or no robotics experience the opportunity to acquire practical experience in a few days. RBL-94 had three major, integral parts: (1) the jump-start session, (2) the laboratory, and (3) three contests. Thirty participants, with backgrounds ranging from university professors and students to practitioners from industry, signed up and devoted a major part of their total time spent at AAAI-94 to the lab. The event lasted a little over 4-1/2 days, starting on the morning of Sunday, 31 July, and lasting until the afternoon of Thursday, 4 August. To provide an idea of what the participants experienced, we briefly describe each part of RBL-94.

### The Jump-Start Session: Getting into It

The only required skills for participating in RBL-94 were general programming experience and common sense! The additional background necessary for building a working robot was provided in a three-hour jump-start session that was given on the first morning. The tutorial did not attempt to provide a comprehensive introduction to the field of robotics but, rather, focused exclusively on issues relevant to the lab component of RBL-94. Thus, it provided a working knowledge about the lab materials and gave some background information on the general principles. The following topics were covered:

Mobile bases: This topic covered principal design issues, including the different methods of locomotion, steering systems, kinematics, and gearing. We provided detailed examples of how to construct sturdy LEGO structures and how to build dependable gear trains. Additionally, we showed examples of LEGO designs for synchrodrives and differential drives.

Motors and power supplies: Different motor types were discussed, with an emphasis on direct-current (DC) motors and servomotors. We presented diagrams of DC motor characteristics and information on controlling them efficiently. Batteries and their interface to the microcontroller board and motors were also discussed.

Sensors: This section of the tutorial consisted of a general overview on sensor technology, including discussions on analog and digital sensors, active and passive sensing devices, the sensitivity of the various types of sensors, and the specific sensors provided in the robot kit. Most of these sensors were simple tactile (microswitches) and light sensors (photocells and phototransistors), but we also provided parts to build active sensor arrangements, for example, slotted optical switches and modulated infrared sensors. We demonstrated how these sensors could be used to detect collisions, follow lines, and build shaft encoders.

Hardware: The hardware in the robot kit—the 6.270 microcontroller boards—consisted of 3 printed circuit boards acting as the

main controller itself plus 2 small special-purpose boards. We presented a description of the main 6.270 board, its interfaces, on-board switches, and input-output (I-O) ports. A brief description of the 6811 processor that was used and its memory map completed the section on the robot hardware. We also explained how to operate and use the 6.270 board and provided some hints for debugging code running on the board.

Software: The final tutorial section presented the IC language and programming environment used with the 6.270 boards. IC is a small C-like robot-programming language with an interpreter that runs on a host computer. It facilitates program down loads to the board and the interactive execution of commands, entered through the host computer, on the 6.270 board. IC provides simple multiprocessing capability on the microcontroller. This capability is needed for implementing robot-control architectures such as Brooks's (1990a, 1990b) subsumption architecture. The most important feature of IC, however, is its library of special-purpose I-O functions that bridge the gap between the real world (sensors, motors) and the control software.

Supplementing the 6.270 course notes (Oberoi 1994) that were provided was a copy of the jump-start tutorial notes (Graham et al. 1994).[3] The tutorial notes were a quick reference to the course notes and seemed a useful reference during the lab. Several copies of the book by Jones and Flynn (1993) were also available for further reference. A follow-up tutorial session was given the next day to provide participants more insight into robot programming. An overview of the basic control architectures (deliberative, reactive, and hybrid) was presented. Furthermore, we presented an example of a simple subsumption architecture and its implementation in IC. Because this follow-up tutorial was held after the first contest, it provided an opportunity for participants to discuss problems with their initial robot designs and software. During this discussion, the initial experiences of several groups were shared among all participants. For certain problems, for example, good bumper design, we showed some possible solutions.

## The Lab: Building a 6.270 Robot

The lab began immediately after the jump-start session. Participants were grouped into 8 teams of 2 to 4 members and assigned a table, a PC, and a 6.270 kit. All boards were pretested for the teams. Motors, batteries, and most sensors were wired for immediate use. Teams were required to solder special-purpose sensors such as slotted optical switches and infrared proximity sensors. Each PC was preinstalled with IC and ready to go. The laboratory was accessible to the teams 24 hours a day throughout RBL-94. The lab was continuously supervised by organizing committee members and teaching assistants. They all took turns doing the late-night and early-morning shifts. The lab supervisors assisted teams with any problems, from soldering special sensors to providing construction advice to discussing implementation details of robot architectures. While unpacking the kits, the teams spent some time familiarizing themselves with the LEGO parts and generating initial ideas for a mobile base. Afterward, many teams divided the work among themselves: one person to build the base, one to attach and build sensors, and one to program the 6.270 board.

When you consider the uniformity of the kits and the first competition only 24 hours away, many different robot architectures evolved quickly. After some initial trials with more complex mobile bases, most teams decided on a variant of the differential-drive mobile base (recommended in the tutorial because of its simplicity and utility). The importance of testing was strongly emphasized in the tutorial. Many teams took this advice seriously and started early test trials of potential designs. The mobile base could be tested without programming using a manual-motor switchboard. Sensor characteristics were discovered using IC to interactively read sensor values under various environmental conditions (different-colored surfaces, different light levels). Teams discovered early that many design-program-test cycles were needed to get the mobile robot to behave robustly. Naturally, the quality of the experience obtained by the participants depended on many factors, such as team size, teamwork, and even the choice of the mobile base design. The following lessons were learned by the participants: (1) a strong understanding of what sensor unreliability truly means; (2) a feeling for the interdependence of mechanical design and sensor design (for example, bump sensors designed to detect collisions failed to do so because of poor mechanical design); (3) an understanding of the *ripple effect,* where something that seems small and harmless, such as a minor mechanical change (for example, a modified gearbox), can cause even more robot-control and software changes; (4) a strong understanding of the complexity and problems emerging from the integration of many components, each of

which is thought to have been well understood, well designed, and debugged; and (5) an appreciation of good teamwork and the realization that it takes more than one person to make it all work.

Participants decided how much time to devote to their robot. Most teams worked through several night shifts; some even slept in the lab between shifts. This RBL-94 spirit was fascinating to watch and experience. Cooperative behavior emerged many times, with teams ordering pizza and coffee or helping each other solve persistent problems. Most importantly, everybody seemed to have fun. The public was permitted in the robot exhibition hall during the day to share in the robot-building experience. The lab was located adjacent to the "big" robot playing field and attracted many conference attendees who watched the teams work on their robots. The lab ended on Thursday at noon, giving everyone two hours to prepare for the final contest.

## The Contests: Feeling the Competition

The three contests, held publicly on the second, fourth, and last day were the most enjoyable part of RBL-94 as well as the most visible and exciting events. AAAI-94 visitors enjoyed watching the little animate creatures named ROTAGILLA, WEEBLE, TRIDOX, ARGO, FIDO, DARN, CYCLOPS, and DARK HORSE competing in the contests. The contests, in addition to their entertainment value, should be an integral part of any robot-building laboratory. This latter point is alluded to in Martin (1994). The contests help focus designs, guide construction, and direct lab activities toward solutions. In addition, the desire to compete with a working, robust robot is a strong motivating force throughout the entire lab.

Instead of having only one or two unrelated contests, we decided to stage a series of contests tracking the different stages of robot development. Each contest was designed to require some new robot skill in addition to those required in the prior contests. The contests paced the evolution of the robots. By providing competitive feedback early in the robot's development (as opposed to constructing the entire robot only to find out too late that it does not work), teams had time to correct design mistakes and improve performance. The contests also revealed clever design choices that were quickly incorporated into other robots.

The RBL-94 contests shared a common format. Each contest consisted of several rounds, where two robots competed directly against each other. All robots constituted a league in which each robot competed against all the others (each robot competed in 7 rounds, yielding 28 rounds to a contest). The same table was used for all contests (walls and obstacles were added in the second and third contests). The table had two designated starting positions in which robots were placed to face one of four possible directions determined by coin tosses. Beneath each starting position was a light bulb. The two light bulbs were switched on simultaneously to signal the start of the round. The robots were then allowed a fixed period (60 or 90 seconds depending on the contest) of motor run time. At the end of the fixed time period, the robots had to stop moving or be disqualified. Prior to the contests, all the teams were provided with detailed contest descriptions and rules. The robot winning the most rounds was declared the contest winner.

### Contest 1: It's All Uphill!

When the first contest was held, the robots, now barely 27 hours old, were required to perform the simple task of moving from the starting area to the goal area (figure 1). The goal of contest 1 was to have teams build an appropriate base capable of controlled movement. This capability was needed for contests 2 and 3. The contest table included one wall and a ramp. The wall was for testing basic movement skills, and the ramp tested robot strengths necessary for later contests (for example, robots that are strong enough to climb the ramp would likely be able to push around the small objects in contest 3).

Design choices made for contest 1 included gear ratios (torque versus speed) and simple sensor integration (detecting the start and goal lights, detecting collisions). The robots' starting positions (left or right) and their orientation (north, south, east, west) were determined randomly at the start of each round to discourage the use of dead reckoning as a control strategy. Some teams used the infrared beacon to determine their starting position and direction. Other teams chose to reactively navigate toward the goal beacon, relying on bump-and-turn behaviors to avoid the wall. The wall and ramp forced teams to build robots capable of changing direction (turning). This lesson was learned from a similar event held in Erlangen, Germany, where the first contest was simply a drag race. Clever teams in this event built robot bases with fixed axles incapable of turning. Their speeds approached five miles an hour, but the chassis was useless for the subsequent contests.

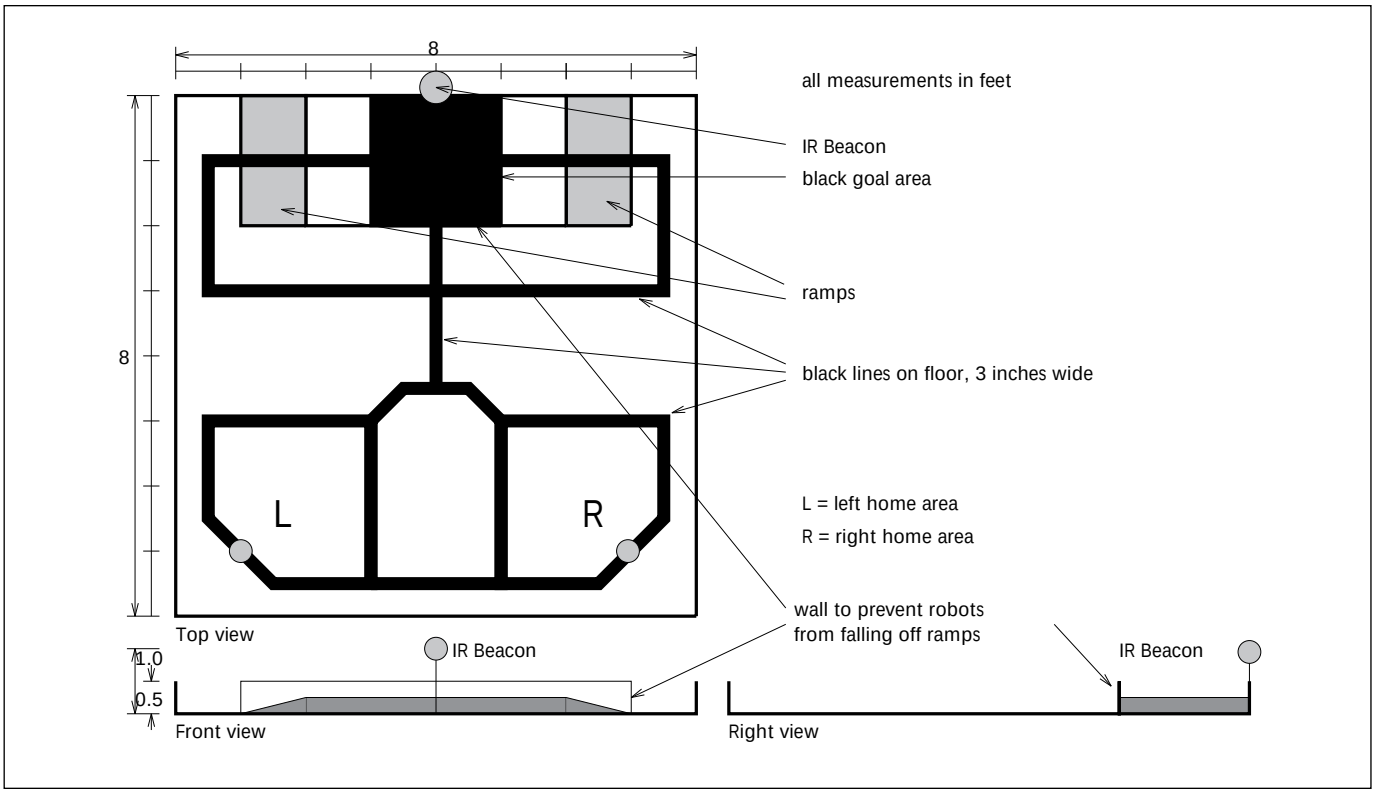


*Figure 1. Contest Table Layout for Contest 1.*

The scoring scheme was simple: Each round was worth one point, and any robot making it to the goal area got a point. If neither robot made it to the goal area, the one closest to it got the point. Many surprising things were observed during the rounds. Some robots failed to notice the starting light; others were running old or incomplete control software. As the contest proceeded, teams became more accustomed to the contest situation. Robot performance improved. Some brave teams even made code changes between rounds. The result was that as the rounds progressed, more and more robots were successful in reaching the goal area.

In the final round, ROTAGILLA was leading. CYCLOPS was trailing by one point. CYCLOPS won its round convincingly, forcing a playoff with ROTAGILLA. In the playoff, both robots made it to the goal! The judges decided to repeat the playoff and modified the rules so that the first robot reaching the goal area would be declared the contest winner. The robots switched starting positions, and the race began. ROTAGILLA wedged itself at the ramp wall. CYCLOPS performed flawlessly to become our first winner.

**Contest 2: Out of My Way!** Two days later, the second contest was held. Although the goal of contest 2 was unchanged from contest 1, the task was made more difficult with the addition of walls to the contest table (figure 2). The robots now had a maze to negotiate!

Contest 2 focused attention on control architectures. The added complexity of the maze tested design choices, some of which were reactive planning, dead reckoning, subsumption, and line following. The pattern of black lines on the table floor could be used to negotiate the maze. Line following was only successful for those robots capable of also tracking the infrared beacon—a shocking revelation to teams whose robots circled around the left and right starting positions unaware that the lines formed cycles.

The idea of line following was tempting but was not without problems for roboticists with just three days of experience. They had to make several decisions: What method should be used to initially acquire the line? What should be done if the line is lost? Can the line intersections be detected? These problems deterred most teams. The alternatives were not elegant. Navigating the maze by just bumping into walls was an unreliable strategy given the inaccuracy of the LEGO base. Dead reckoning was unattractive for the same reason. Most

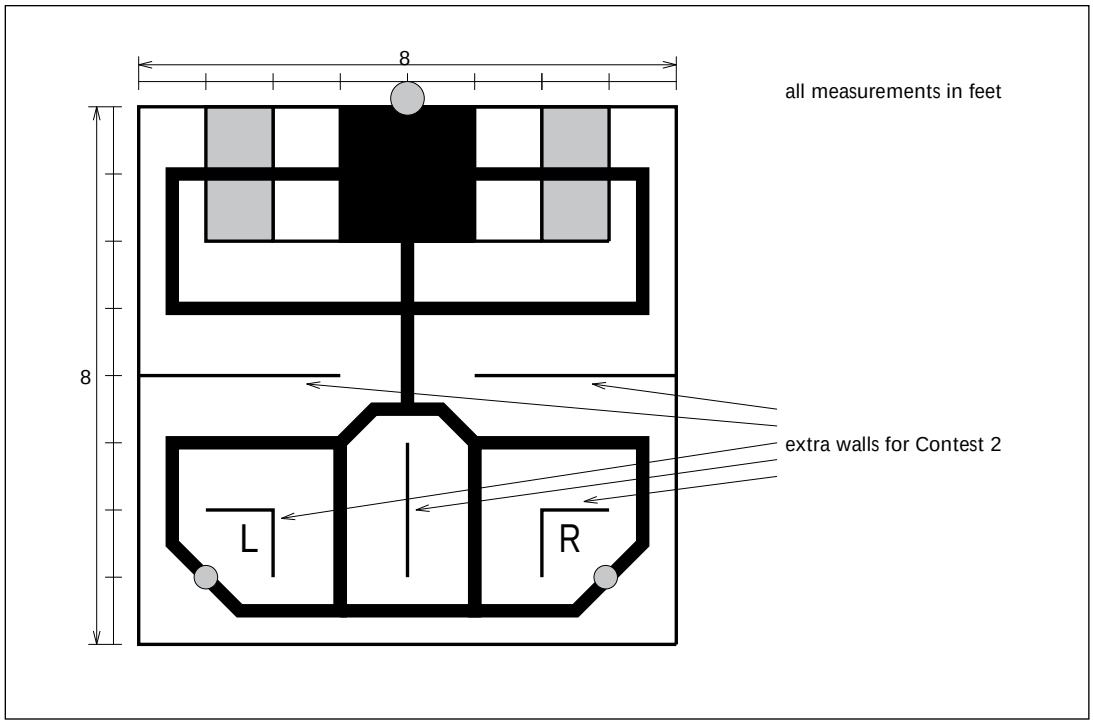


*Figure 2. Contest Table Layout for Contest 2.*

teams implemented a mixture of strategies, such as "line follow until it is lost, then resort to beacon tracking and bump behaviors to reach the goal." Given that the task had become significantly more difficult, not many robots were expected to succeed repeatedly. A slight modification of the scoring scheme was required to prevent tie scores and reward partial success. Points would be awarded for reaching certain areas of the table.

The rounds of contest 2 were even more exciting to watch than those of contest 1. Some robots made it halfway through the maze, then got stuck at a wall and ignorantly decided to return home. Many dead-reckoning robots got confused, as a result of collisions with the other robot, where some of the lines merged in the middle of the table. The bump was misinterpreted as a wall and caused comic reactions. Still other robots fell victim to the loops formed by the lines, circling round and round for the entire 60 seconds. Nonetheless, robot performance in contest 2 improved over contest 1. Another tie score forced another playoff, and DARK HORSE emerged the winner.

## The Final Contest: Scavenger Hunt

The final contest was held Thursday afternoon. By now, the teams had spent more than four days and nights in the lab. The table layout is shown in figure 3.

In contest 3, the robots were required to locate small black cubes in the goal area and return them to their starting position. The table was unchanged from contest 2, but 90 seconds were allowed to accomplish the more difficult task. This contest was believed to be a logical step in the evolution of the robots. The goal was to have them purposely manipulate their environment instead of simply react to it.

Although contest 3 had just one additional task over contest 2, leading to the expectation that at least those robots that succeeded in contest 2 would do so again and thus find the black cubes, performance degraded. The added complexity of manipulating the real world led to radical changes and elaborate gripping devices that rippled problems through the robots' control architectures. In the tutorial, we advised teams to let the robots simply push the cubes and discouraged the construction of complex manipulation devices. Those teams not heeding the advice performed poorly. Scoring for contest 3 focused on how many black cubes were moved away from the goal area. Outside judges were used. They included Pete Bonasso, David Hinkle, Benjamin Kuipers, and Don Perlis. Their job was not always easy. No scriptwriter could have done better for contest 3; two robots had tied scores going into the final round. What a final! DARK HORSE won again.

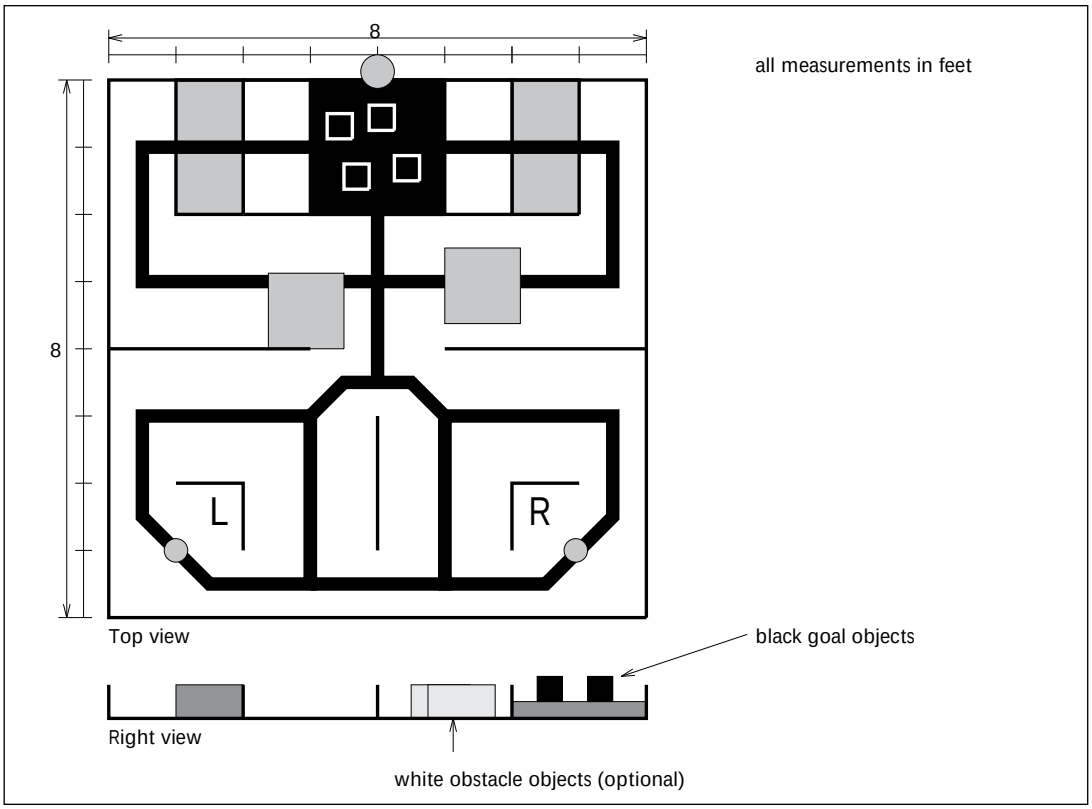


*Figure 3. Contest Table Layout for Contest 3.*

## RBL-94 at AAAI-94

As the organizers of RBL-94, we share the common goal of making RBL an annual stand-alone event at each AAAI conference. Motivations for RBL included improving public awareness and appreciation of AI, promoting mobile robotics and AI, and providing practical robot-building experience to AI researchers. Throughout the AAAI conference, RBL-94 received strong public support. Teams from the big robot competition frequently visited the robot-building lab to check the progress of the small robots. The lab was open to the public during the day, and many conference attendees took time to watch the LEGO construction and ask questions. The contests were clearly the main attraction of the lab. Journalists from *The Seattle Times* reported on the results of contest 1 in a feature article, including an eye-catching photograph of an RBL-94 team working on its robot. The local King 5 TV station also visited the lab. They filmed teams in the lab, interviewed several participants, and recorded the second contest. A 5-minute report about RBL-94 was aired during a late-evening newscast.

## Lessons Learned

Several lessons were learned by both the participants and the organizers. The key lesson learned is that theory and computer (or mental) simulation is no substitute for the real thing, that is, actually building and experimenting with a real robot. The following list highlights some of the lessons learned in RBL-94. It is meant for the benefit of those who are interested in organizing future robot-building labs.

First, a tutorial providing a minimal amount of robotics knowledge is essential. However, unlike the AAAI-93 Mobile Robot I tutorial, the RBL-94 jump-start session was tailored to the RBL-94 lab. Also, whenever we presented examples for mobile bases, gear trains, sensors, motors, or hardware and software, we simply used the tools and technology available in the lab.

Second, the main part of the course is the lab. Building a robot takes a lot of time, and cramming it into a few days means that the lab must be open to participants at all times. Many participants spent several nights working and got little sleep. Most can put up with one “all-nighter,” quite a few two, but only a

very few can make it through three. There should be periods where the lab is closed so that participants can take a breather. For example, a break period can be provided by closing the lab for a night of rest right after a demanding contest.

Third, teaching assistants are indispensable and must be available all the time. They can help fill in with any areas not covered in the jump-start session.

Fourth, the contests play an important role. They are the main—and sometimes the only—motivating factor after the first couple of failures are encountered during lab hours. The experience of RBL-93 showed that having two final contests, which require different robot capabilities, at the end of the lab is usually too much to ask for. It was better to instead have several consecutive contests that built on each other. This idea proved to work out well in RBL-94, although the different contests need to be designed carefully. Although contests should incrementally increase the required robot capabilities and programming efforts, one must ensure structural uniformity and avoid overly complex tasks. Structural uniformity refers to mechanical features of the robots and means that every robot capability required for the final task must also be required—although in much simpler form—for the first one. If the final contest requires climbing a ramp, making turns, or lifting an object, then the first contest should require the robot to make a turn, climb a ramp, or lift an object. If this is not the case, teams have to significantly rebuild their robots for the different contests. Also, if the task is too complex, then it might not be possible to solve it in the available time frame or at all, leading to frustration among participants and severely endangering the overall lab goals.

Fifth, because the robot kit is the most costly part of the budget, the organizers discussed using a different, cheaper kit. However, because of the cost and time pressure involved in getting the kits together, the decision was made to go with the 6.270 kit. This decision might continue to be true in the near future for robot-building labs in general. However, for future labs to be successful and more widely accepted, the price for the robot kit has to come down. Future lab kits should have a more open configuration, with options for using construction parts other than LEGO or even new microprocessor boards or a new development environment. Arbitrarily locking all future robot-building labs into a single robot configuration will make it difficult for the robot kit to evolve with new technology.

Sixth, to help ease the cost of organizing a robot-building lab, it is necessary to solicit corporate sponsorship. However, this task is not an easy one. For this reason, it is important to start soliciting corporate support as early as possible. Also, because many arrangements for the lab equipment and the robot kits must be made well in advance, some financial planning is necessary for the advance funding of such activities. Finally, a well–thought-out advertising campaign aimed at robot groups in companies, universities, and schools and on the Internet can help attract a sufficient number of participants.

## Future Plans

Robot-building labs have proven to be valuable conference events in several regards: (1) they are an interesting new teaching and learning concept, (2) they provide a forum to meet new people and exchange ideas, (3) they enrich the overall conference atmosphere, and (4) they increase attendance. Last but not least, they are a lot of fun for participants, organizers, and the general conference audience. For these reasons, several of the RBL-94 organizers are initiating similar events in the future. In particular, one group, headed by Jeff Graham and Josef Schneeberger, leads the effort to organize RBL-95, perhaps in conjunction with the Fourteenth International Joint Conference on Artificial Intelligence (IJCAI-95) (subject to the approval of an RBL-95 proposal submitted to IJCAII by the RBL-95 committee). The other group, informally coordinated by Willie Lim, plans to organize robot-building competitions at the national level.

Before presenting detailed plans, some general thoughts about future directions are in order. The concept of a robot-building lab is clearly not fixed and offers significant freedom for creativity, variation, adaptation, and innovation. Some changes might be wise to make or might even be forced by future developments in platforms: new, improved hardware; cheaper tool kits for building mobile bases or ready-made mobile bases; better software environments; and new sensor technology. As always—and as pointed out previously—there is a lot one can think of, but only a small portion of it makes sense to actually include. The reasons are always the same: New technology is either too expensive and too complex to be learned and applied in a short time, or it is cheap but

inadequate to do anything useful with it. To manage complexity, some people suggested providing more things off the shelf or in libraries, for example, a prebuilt mobile base or line-following code. However, the more complex the basic building blocks get, the more complex they are to understand and apply. Also, participants learn a lot by just encountering all these low-level problems. A reasonable and desirable enhancement would be to provide more demo design for mobile bases, sensor arrangements, and software. A much more promising direction might be to integrate future robot-building labs more closely with other robotics events, especially with the annual AAAI robot exhibition and contest. It would give participants an opportunity to learn from more experienced people. An interesting idea here is to have joint or similar contests, where big robots and small robots either have to achieve the same or similar tasks in the same environment. They could compete or cooperate. It would definitely be interesting to see what the differences in behavior are and what additional capabilities or problems sophisticated technology might buy.

## Plans for RBL-95

During RBL-94, several participants and organizing committee members expressed an interest in organizing RBL-95. As a result, an informal organizing committee for RBL-95 was formed. The primary contacts for this committee are Jeffrey Graham (e-mail: jsgraham@cftnet.com) and Josef Schneeberger (e-mail: schneeberger@forwiss.uni-erlangen.de). Two RBL-95–related mailing lists have also been created: (1) rbl-95@ai.mit.edu for general discussions of RBL-95 and (2) rbl-95-request@ai.mit.edu for requests to join the previous mailing list.

The primary goal of the committee is to organize an event similar to RBL-94. Instead of the jump-start session, a mandatory tutorial is planned, which will be opened to everyone. In addition, tutorial and design review sessions will be held during the lab time to allow for more in-depth presentation and discussion of specific topics as well as give teams an opportunity to discuss their robot designs. Instead of three contests with three different tasks, RBL-95 will probably feature only two public contests plus a nonpublic trial run of the final contest on the last evening of lab time. Aside from this more or less classical robot-building–lab concept, we plan to organize two additional events:

First is the Open Small Robot Competition. More and more research groups and people already own a 6.270 robot kit. We want to invite them to build a robot back home and then come to RBL-95 and compete. The task to be solved in the competition will be announced well in advance. It will be the same as for the final contest of RBL-95. Thus, the audience will be able to see the difference in robot behaviors.

Second is the Open Small Robot Exhibition: This event is merely a forum where people can show their LEGO-based or other small robots. These robots are not required to perform any particular task. An interesting design concept or something neat that a robot can do qualifies you. Participants in this event should come and demonstrate the capabilities of their robot as well as display a poster explaining their idea.

## On to National Robot-Building Labs?

Another future event under consideration is a AAAI-sponsored national lab for colleges. A similar idea involving high schools is also under consideration. However, having gone through the experience of organizing RBL-94, we feel that a two-phase approach is needed. The first phase involves organizing a college-level robot-building lab (perhaps in 1996 or later). The general idea is to have 8 to 16 regional competitions held in the spring, with the winners of these competitions going to the finals to be held as part of the robot-building lab for that year. If things work out, then the second phase would be to organize a similar lab for high schools about two years later, with the finals to be held during the national robot-building lab as well. Hence, at that lab, there will be at least three events: (1) the regular lab, (2) the college finals, and (3) the high school finals. A fourth event, an open final for all, might be added to determine the overall lab champion for the year. The person to contact regarding the national robot-building lab is Willie Lim (e-mail: wlim@ai.mit.edu); the following mailing lists were created for this purpose: (1) national-rbl@ai.mit.edu for general discussions of the national lab (both college and high school levels) and (2) national-rbl-request@ai.mit.edu for requests to join the previous mailing list.

## Acknowledgments

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guided us along during the whole year in preparing for this event. Steve Sanders was our capable local guide to the Seattle, Washington, area, helping us buy and transport materials for contest tables as well as build them. RBL-94 would not have been possible without Frank Brill III and Karl Wurst, the two RBL-94 teaching assistants; many thanks for the great job they did in preparing the lab and assisting participants whenever problems occurred. We would also like to express our deep appreciation to the participants for daring to try it in the real world and making RBL-94 so much fun for all. Finally, we would like to thank the contest judges for their effort.

## Notes

1. A detailed description of the 6.270 history can be found in the Preface of the 6.270 course notes (Oberoi et al. 1994).

2. The 6.270 documentation is available in the directory /pub/ACS/6.270 on the host cherupakha.media.mit.edu.

3. The tutorial notes (about 140 slides) are available from Gerhard Kraetzschmar at FORWISS, Germany, e-mail: kraetzschmar@forwiss.unierlangen.de.

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