

Deriving Consistency from LEGOs

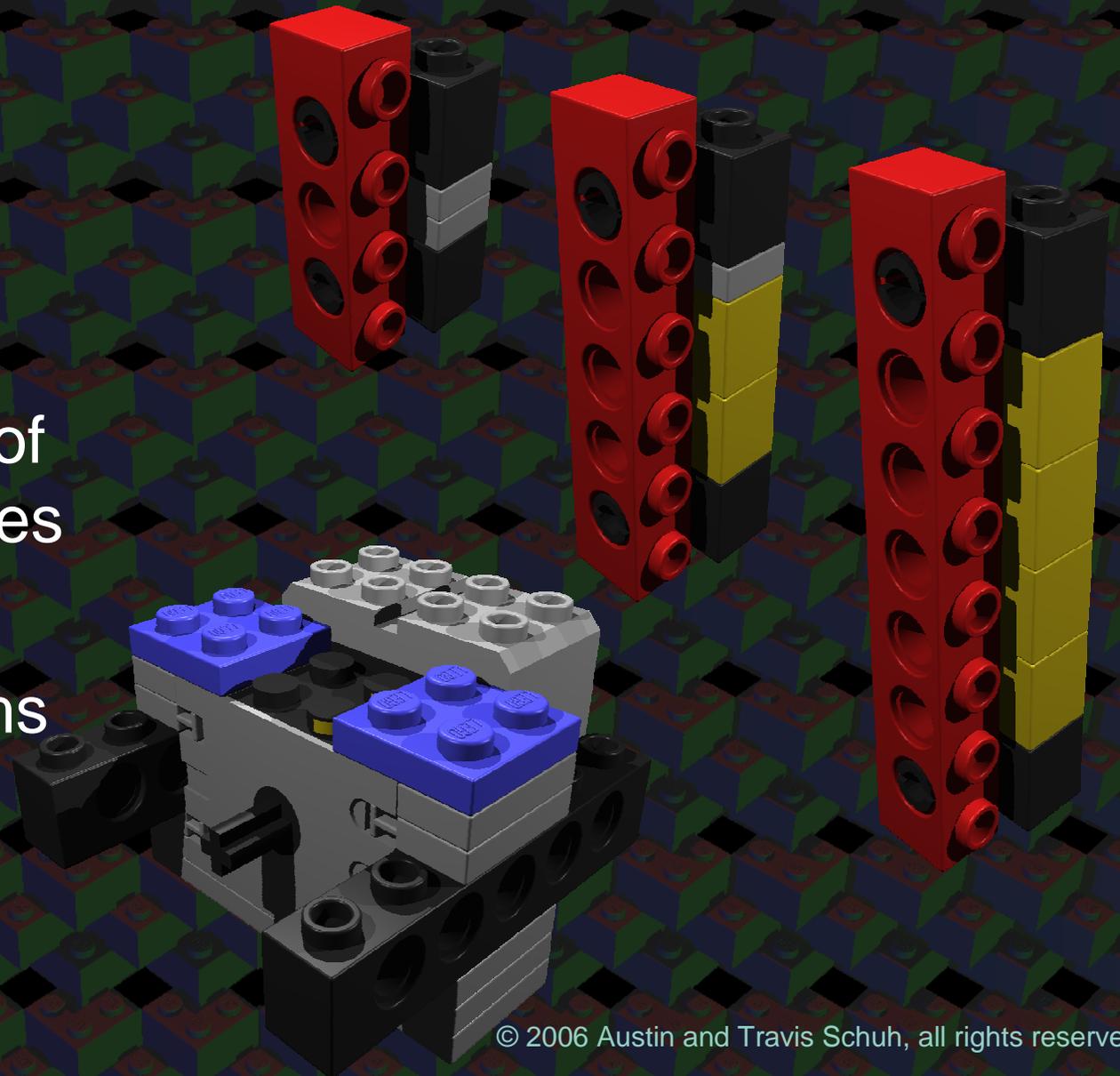
What we have learned in 6 years of FLL
and 7 years of Lego Robotics
by
Austin and Travis Schuh

Objectives

- Basic Building Techniques
- How to Build Arms and Drive Trains
- Using Sensors
- Quick Programming Introduction
- Line Following
- What to do Before and During the Season

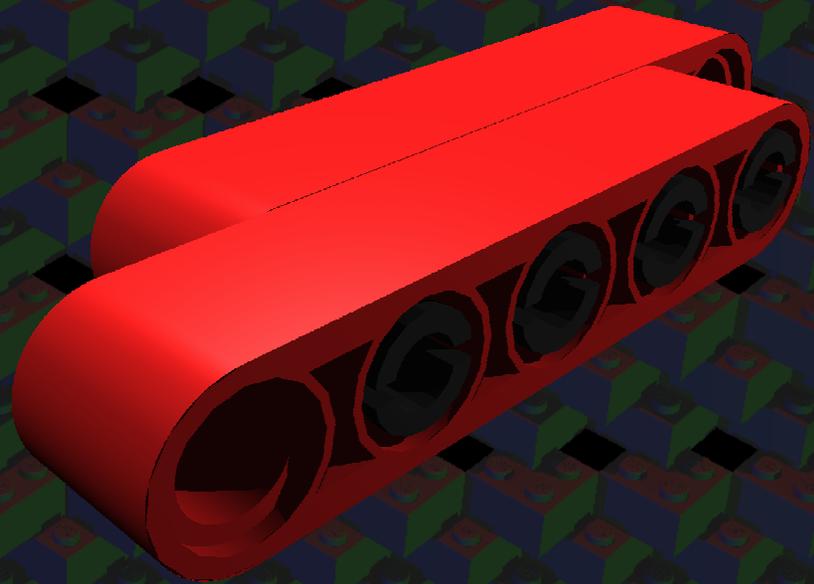
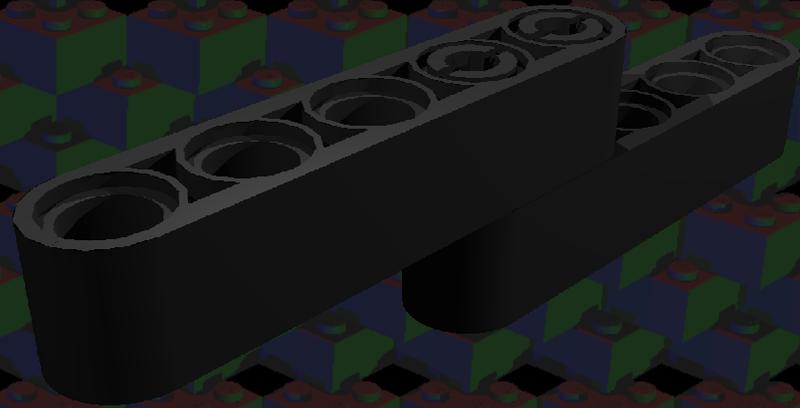
Basic Building Techniques

- Pinning
- Pros and cons of Beams and Axles
- Attaching Beams to Motors



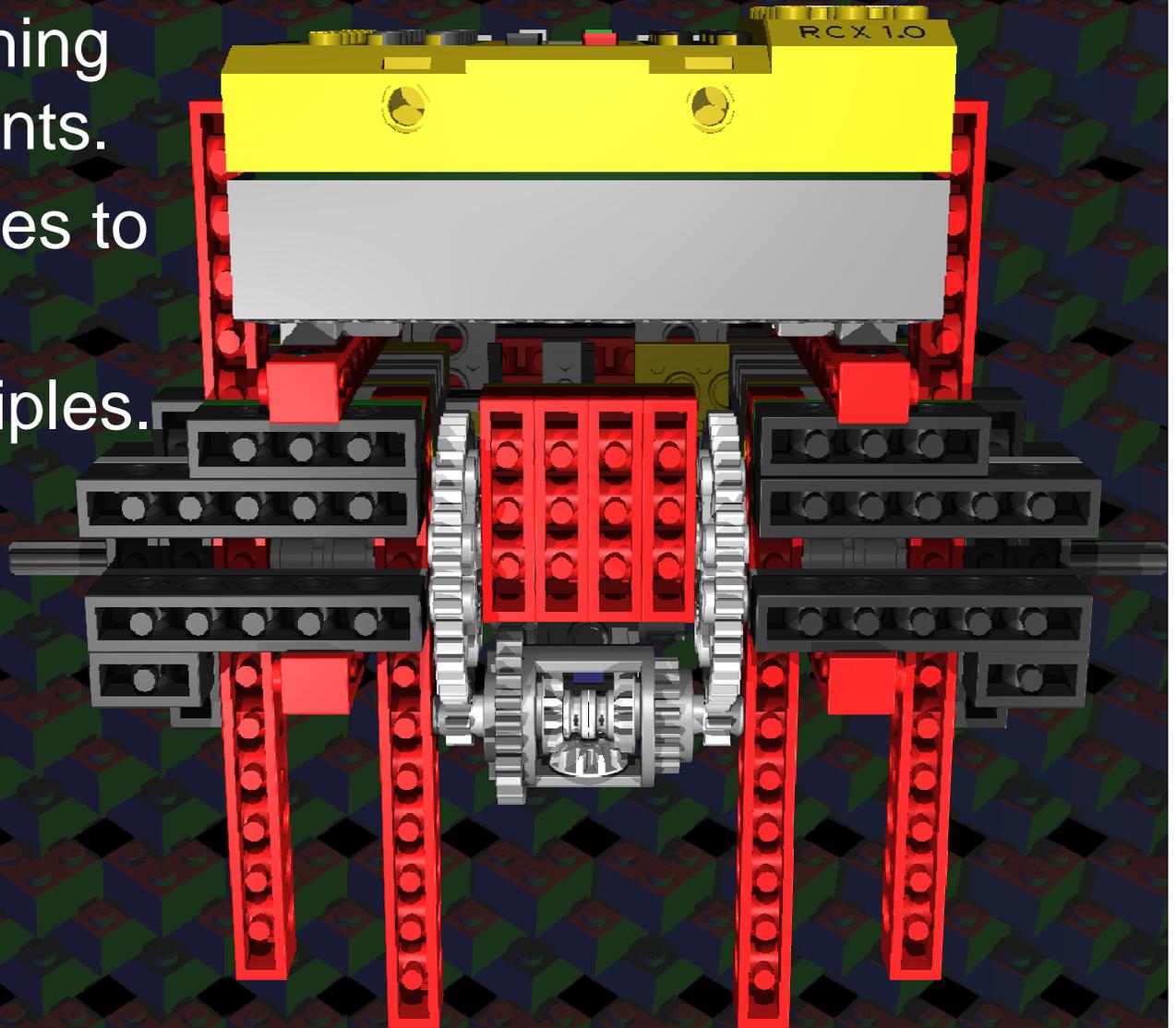
Basic Building Techniques For NXT

- Plan your robot around the robot and controller
- Beams that are pinned together are rigid in only one direction
- The more overlap used, the stronger the connection



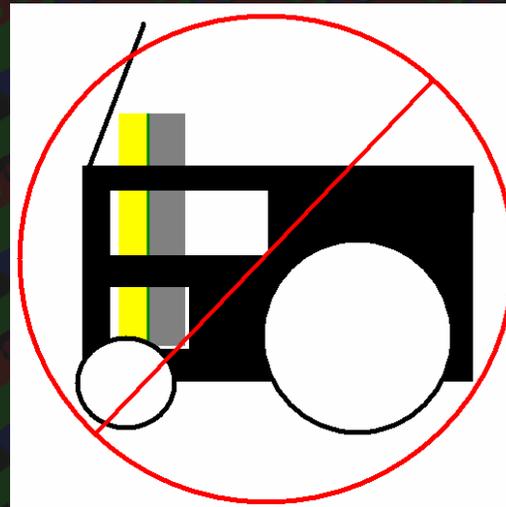
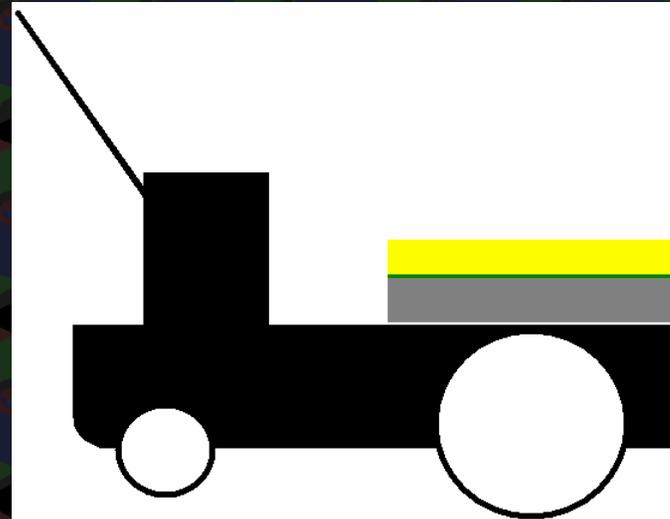
Advanced Building Techniques

- Connect everything by at least 2 points.
- Use right triangles to brace things.
- Pythagorean Triples.



Mounting the RCX / NXT

- It is important to mount the controller where you can easily access the buttons and see the screen.
- Make sure it is easy to take the controller off to change batteries, yet it is securely attached.
- Mount the controller so that the robot will have very little weight on the front wheels.



Testing Strength

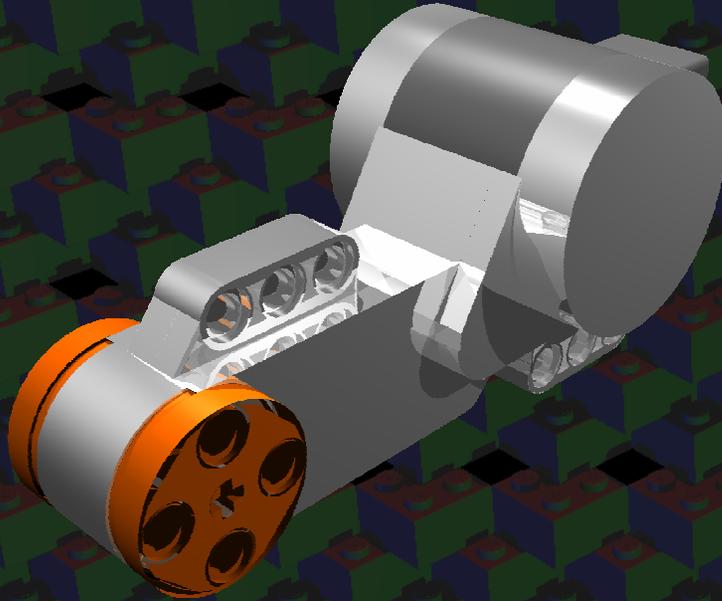
- Coach Test: Have your coach pick up your robot. If they can succeed without breaking it, it passes. Don't give them too many instructions first
- Stall Test: If you can stall all of your motors and the robot doesn't break or threaten to break, it passes.

Testing Strength

- Drop Test: If you can drop your robot a couple of inches, and it doesn't break, it passes.
- Slop Test: Push your robot in all directions lightly, and see how much the gears and frame move before it starts resisting you. Less slop is better.

Motors

NXT Motor



RCX Motor



- Built in Encoder
- Utilizes a PID controller
- No Gearing is needed
- Less Inertia
- Smaller
- More Efficient Brake Function

Things to be aware of: RCX Motor

- Hard to attach it to the robot by the bumps alone.
- Dependent on Battery voltage, unless precautions like a rotation sensor are used.
- Needs to be geared down if any accuracy is required.

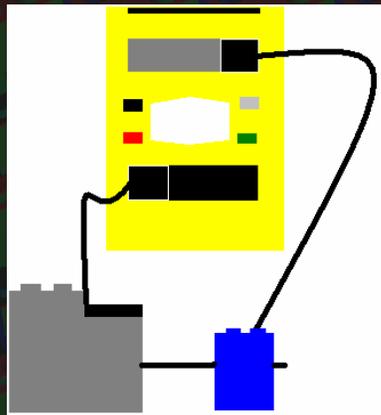
Things to be aware of: NXT Motor

- You can't plug it in backwards.
- Symmetrical
- Putting Gears between it and the wheel results in a harder to control robot
- Battery voltage doesn't effect it

Matching RCX Motors

Match your motors

- Each motor goes at a different RPM, which causes the robots to veer.
- This can be overcome by pairing motors of similar RPM.
- Compare the speed of motors and then choose the two motors with the closest RPM for your drive motors.



Motor Rotation sensor

Have a simple program that turns the motor on for x seconds. Use the view button to find out how many counts the motor turned and then record the number . Repeat for each motor.

Gearing

- The RCX motors themselves go too fast, so gearing down is necessary, but the NXT motors do not need to be geared down.
- Do not use gears to change angles.
- When choosing the speed of your robot, you want to be fast enough to get around easily, but slow enough to have precise turning.
- If using NXT motors with gears, minimize the gear slop.

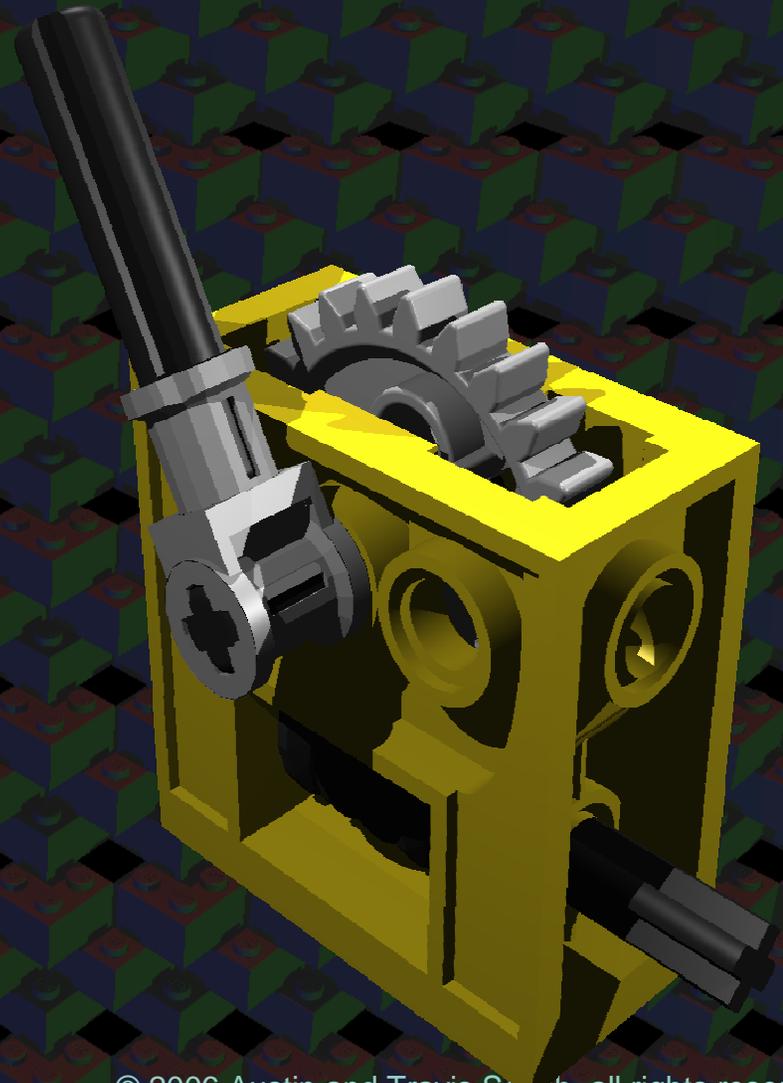


Wheels

- Wheels are like gears, the bigger the wheel, the faster the robot moves; the smaller the wheel, the slower the robot moves.
- Since the NXT motors go at a nice speed to begin with, vary wheel size before trying to gear them up or down.
- Look for a wheel that has lots of traction.
- Check if the challenge has something requiring big wheels (climbing up something).
- Tank Treads are not the most practical form of wheels, lots of energy is lost in trying to spin the treads and they can not go as fast.
- Do not put treads on the front wheels, because treads make turning hard.

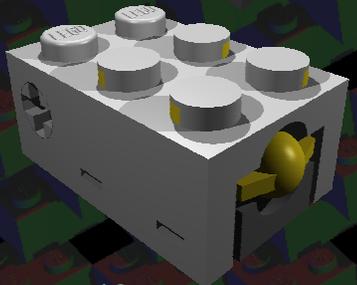
Arms

- The arm's job is to help a team manipulate the field pieces.
- The yellow gear box makes a simple arm for the RCX, but there is lots of friction involved.
- To slow down the movement of an arm, use gears, don't drive it at a lower power.
- It is not necessary to have a motorized arm.
- It is good to be able to quickly change arm attachments, because it is common to have a different arm for each mission.



RCX Sensors

- A rotation sensor counts how many times an axle rotates. A rotation sensor starts skipping counts at around 500 rpm, and the motor operates at 375 rpm, so gear the rotation sensor so that it goes at the same speed as the motor.
- A light sensor measures how reflective a surface is, and returns 100 as the brightest and 0 as the darkest.
- A touch sensor tells the robot when it is pressed or depressed.



NXT Sensors



- The Sonar sensor sends out a pulse of sound and returns a value based on how long it takes for the pulse to bounce off objects and return.



- A light sensor measures how reflective a surface is, and returns 100 as the brightest and 0 as the darkest.



- A touch sensor tells the robot when it is pressed or depressed.

- The motors have built in rotation sensors with 360 encoder counts per rotation. To have the robot be the most accurate that it can be, use the degree measure instead of % of a rotation.

Using the Sensors with the RCX

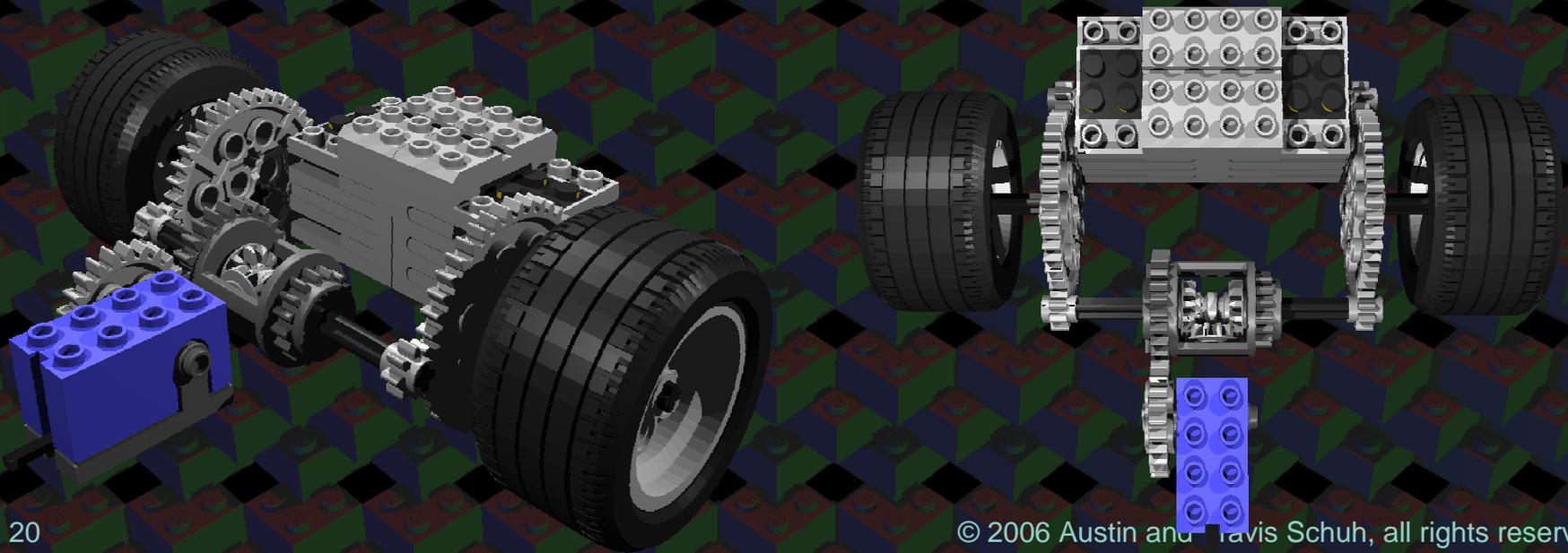
- The RCX has three gray sensor ports.
- To maximize the use of the sensor ports, it is possible to plug a light sensor and a touch sensor into the same port. In your code, you treat the port like a light sensor, except the only difference is that when the touch sensor is pressed, the port returns 100.
- To find rotation and light values, use the view button to select a port by pushing it until the arrow points to the desired port. Then, the screen will display the value of the sensor that is defined as on that port in the code.
- If you hold down the view button while a motor is selected, you can use the Prgm and Run button to test the movement of the motor.

Using the Sensors with the NXT

- There are four sensor ports and the rotation sensors are built in to the motors.
- To view the value of a sensor, go to the main menu. Hit the side arrow until you see the view item. Select it. Select the sensor type you are interested in viewing. Then, select the port number.
- You can use the old RCX sensors with the NXT controller using the NXT to RCX sensor wire converters.
- You can use the sensor blocks in Lego Mindstorms to view the values of sensors. In the bottom left corner of the screen, when the sensor block is selected and the robot is connected to the computer, the block will display the current sensor value. <Demo>

Differential Rotation

- A differential rotation is where one uses a differential and a rotation sensor to be able to get rotation values from both wheels.
- A differential rotation measures distance when going forward, backward, and turning with only one wheel. It does not count rotations when the motors spin in opposite directions at the same speed.



Navigation

- Features to use
 - Following Walls
 - Following Lines
 - Squaring up on Walls
 - Driving until Lines
 - Intersections of features
 - Distance along another feature

Navigation

- Order of use
 - Use available physical features over rotations.
 - Rotations
 - Time

Which Program Language to Use for the RCX

- Both languages use picture programming blocks. There are no other options.
- MindStorms is easier to pick up because it is well documented.
- Robolab is capable of doing higher power things.
- I would recommend MindStorms for first year teams, and Robolab to more experienced teams that want more flexibility.
- In 2003, my team had the highest score at state and we programmed in MindStorms.



What to watch out for when Programming

- If you tell your robot to go forward until the rotation sensor equals 24, the robot might skip seeing the number 24, so it will go forward forever.
- Instead, tell the robot to go forward until the rotation sensor is greater than or equal to 24, so that if it misses seeing 24, the robot will see 25 and then stop.
- Watch trying to give the robot a number that is more exact than it can use. It can not turn the motor for 0.13242194 rotations. It will round it, and you will have a false sense of precision.

What to watch out for when Programming

- The Unlimited move option works differently than expected.
- Negative speed into the function makes it still go forward if the direction specified is forward.



Move

Port: A B C

Power: 75

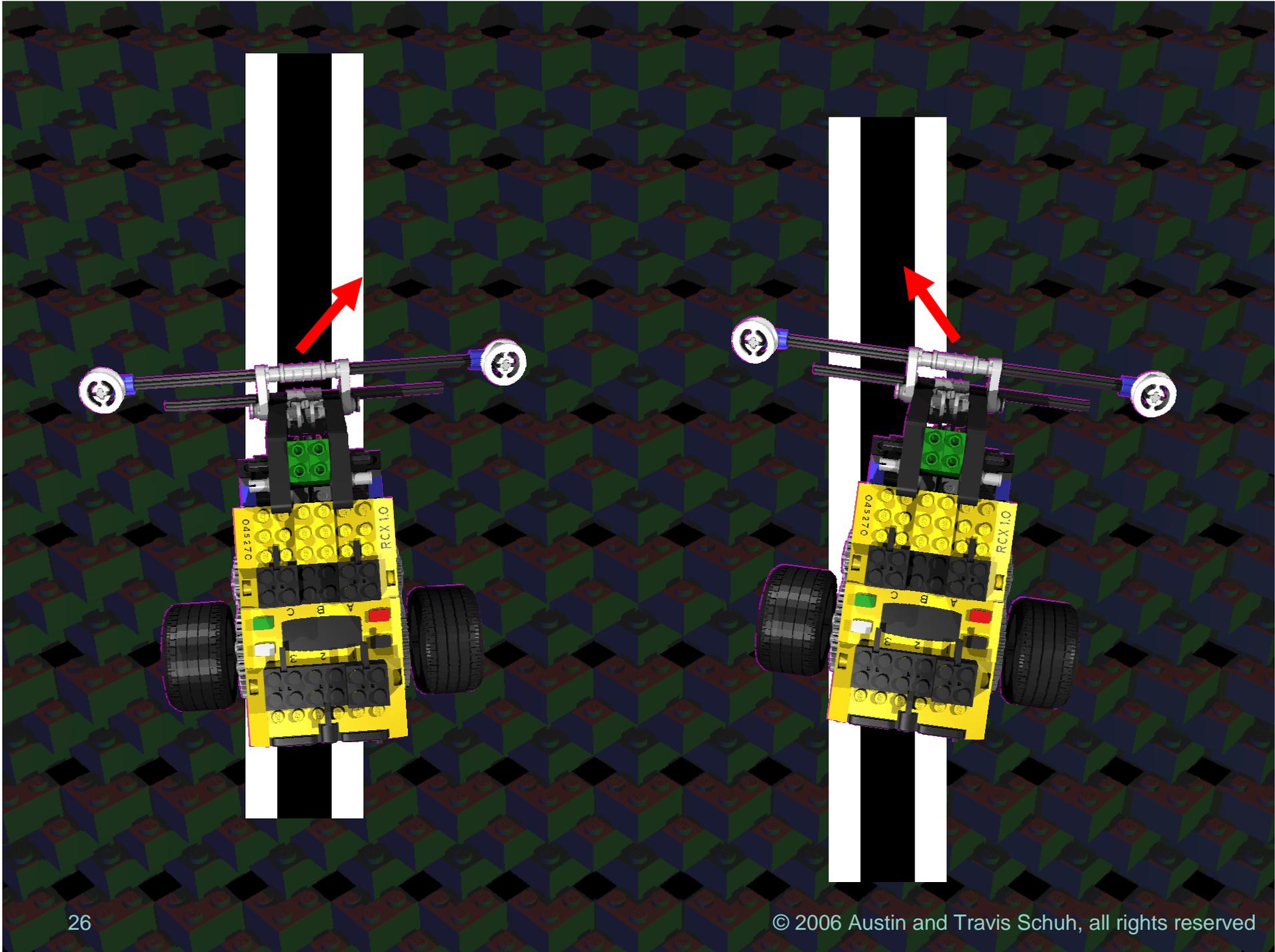
Direction: ↑ ↓ ↻

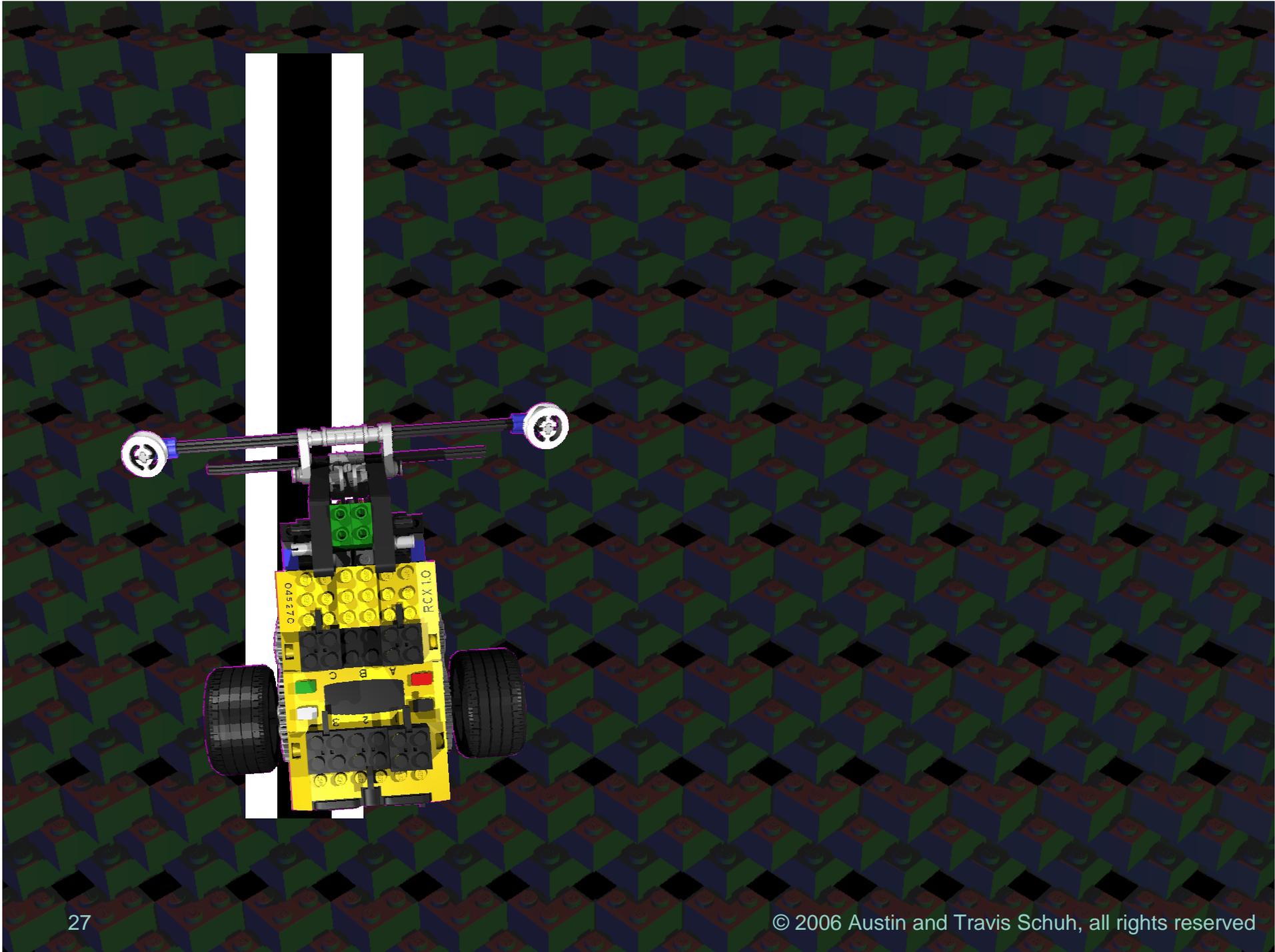
Duration: 360 Unlimited

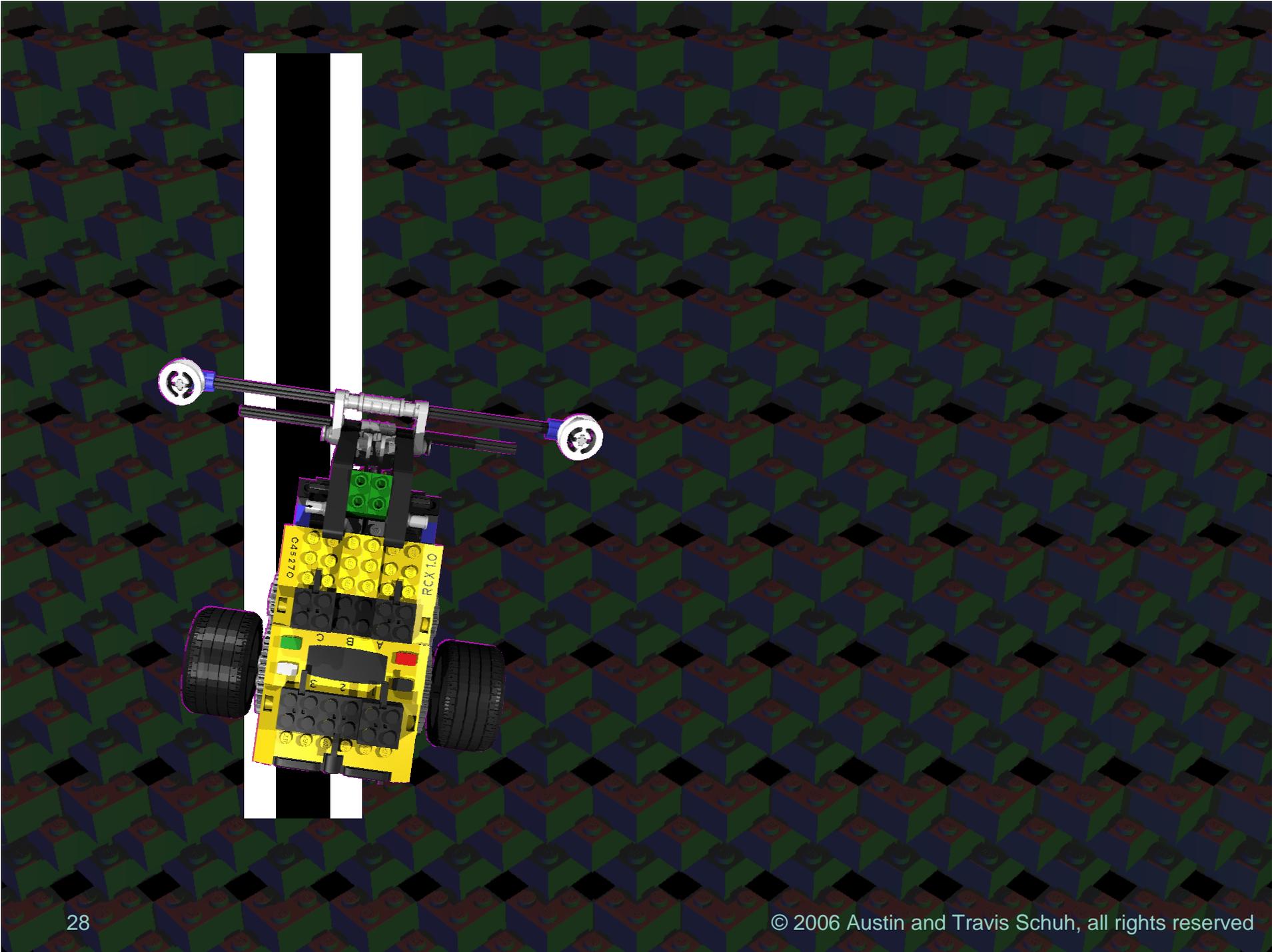
Steering: C B A

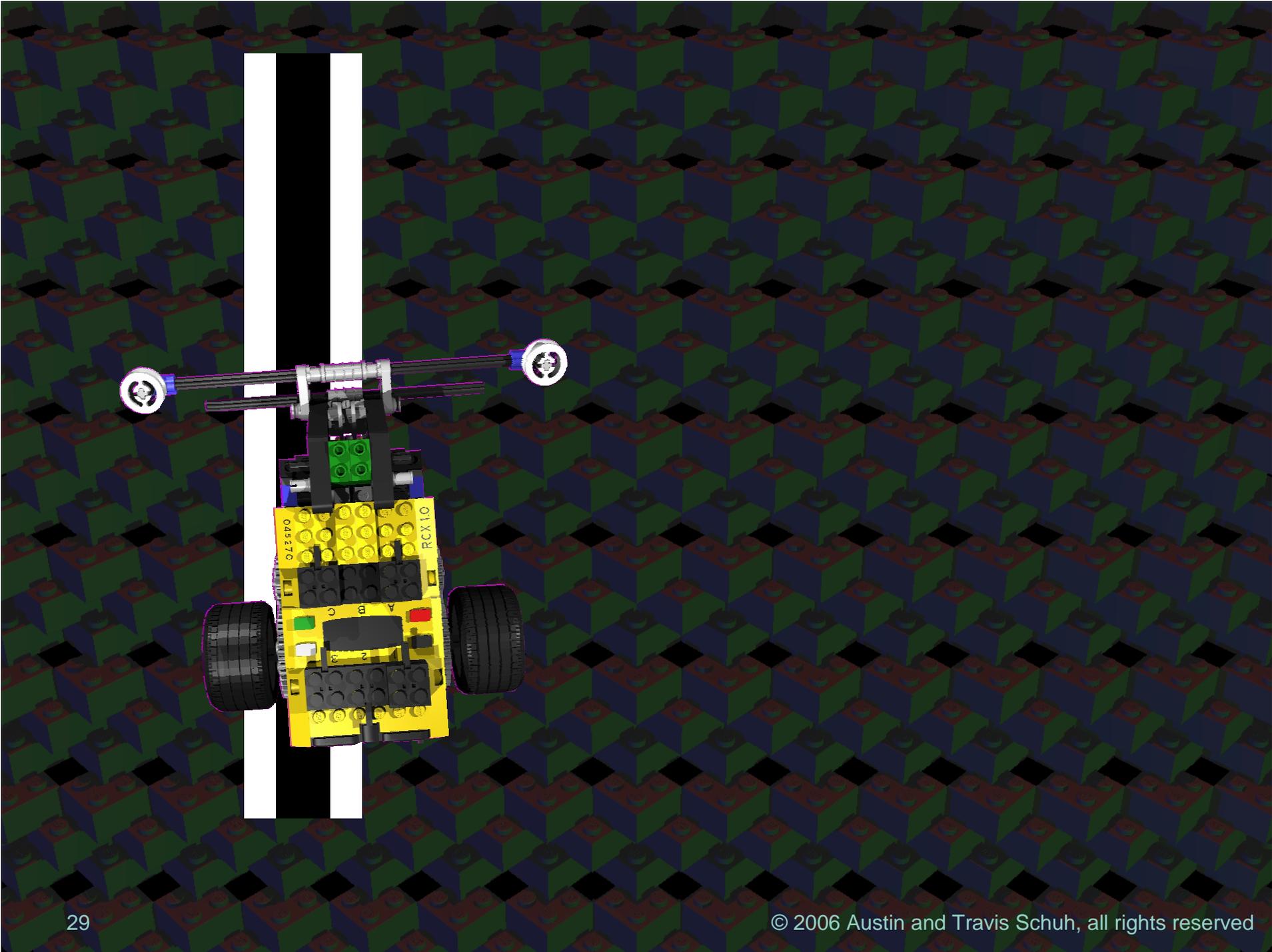
Next Action: Brake Coast

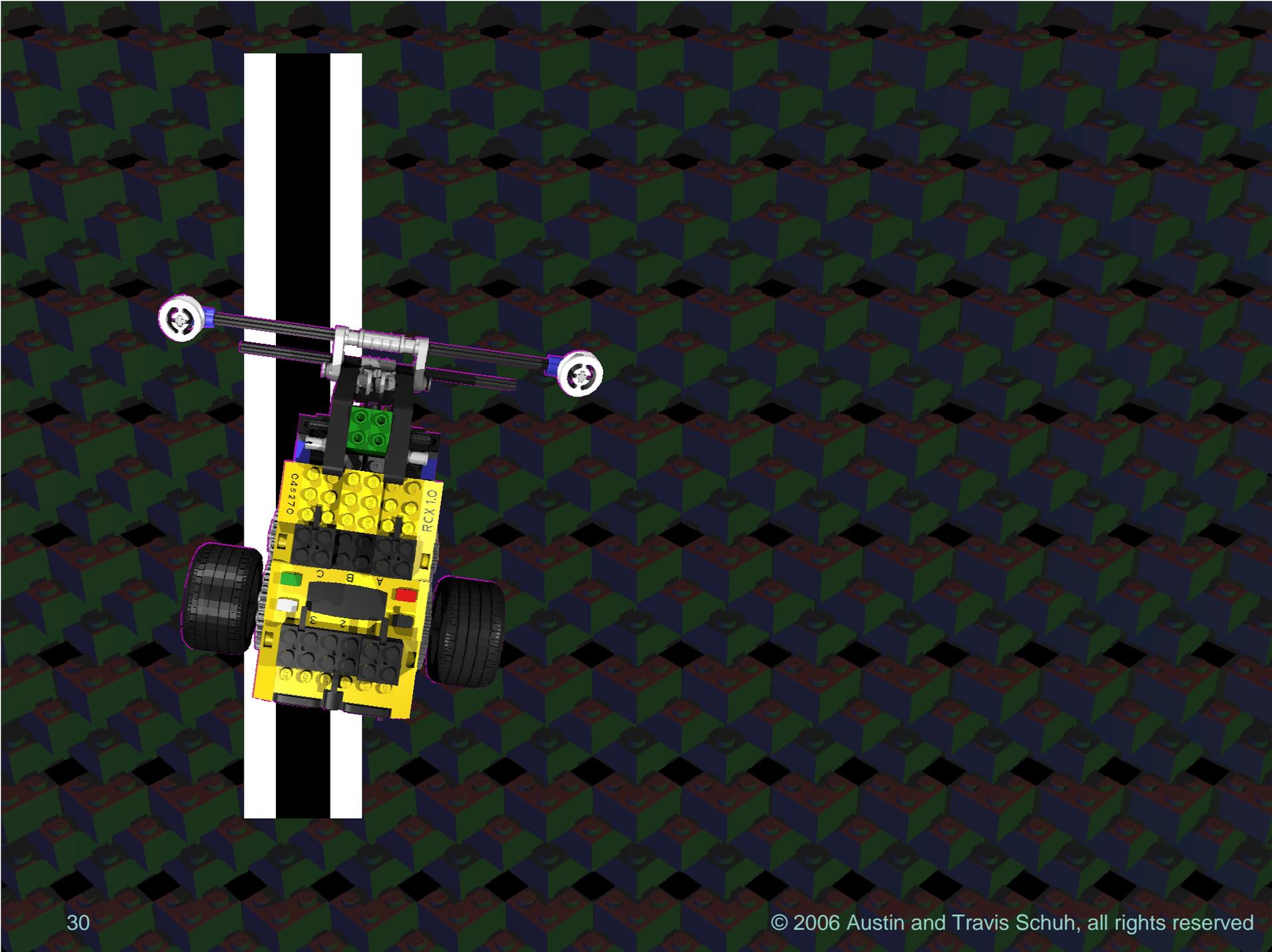
reserved

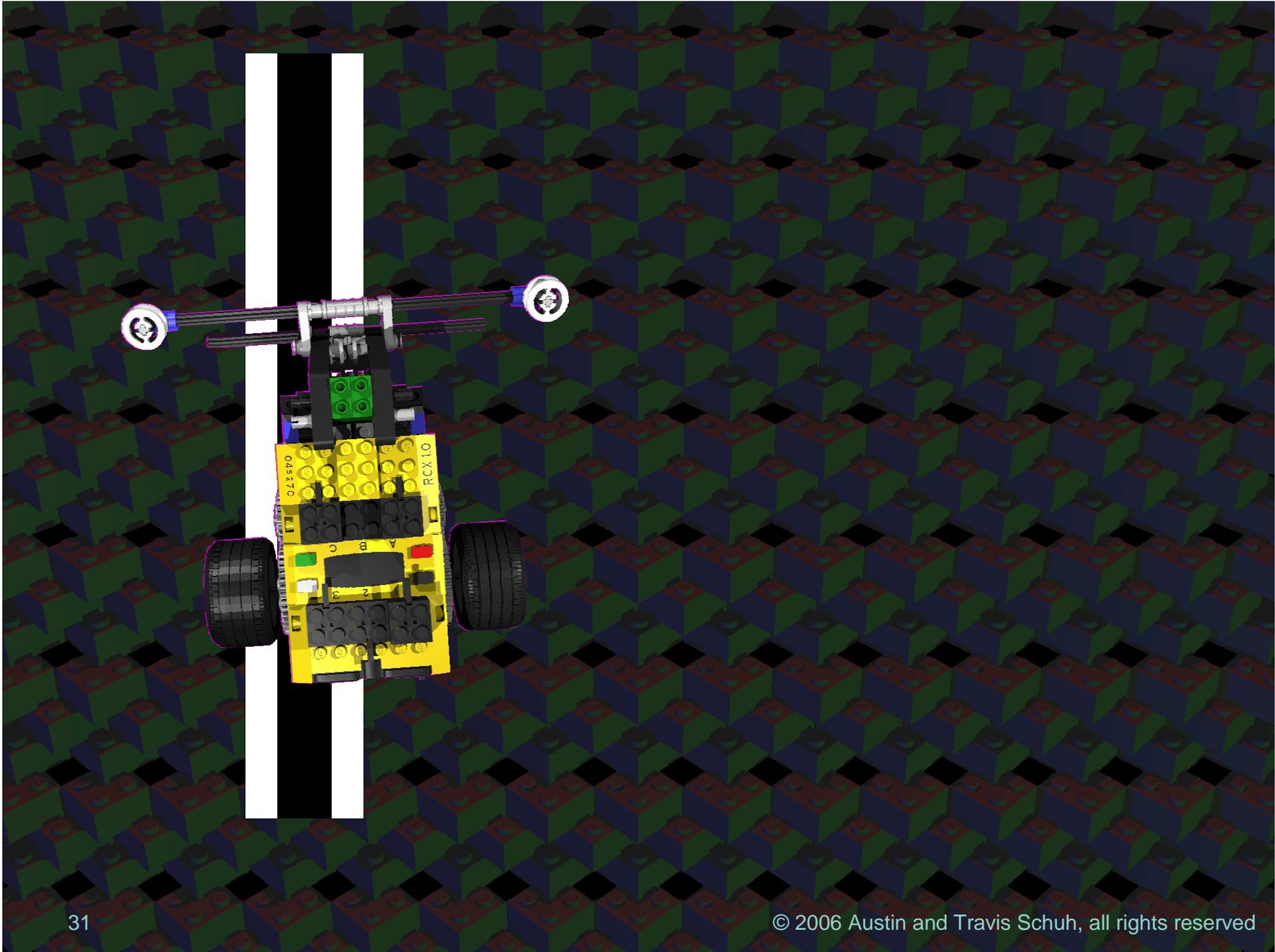


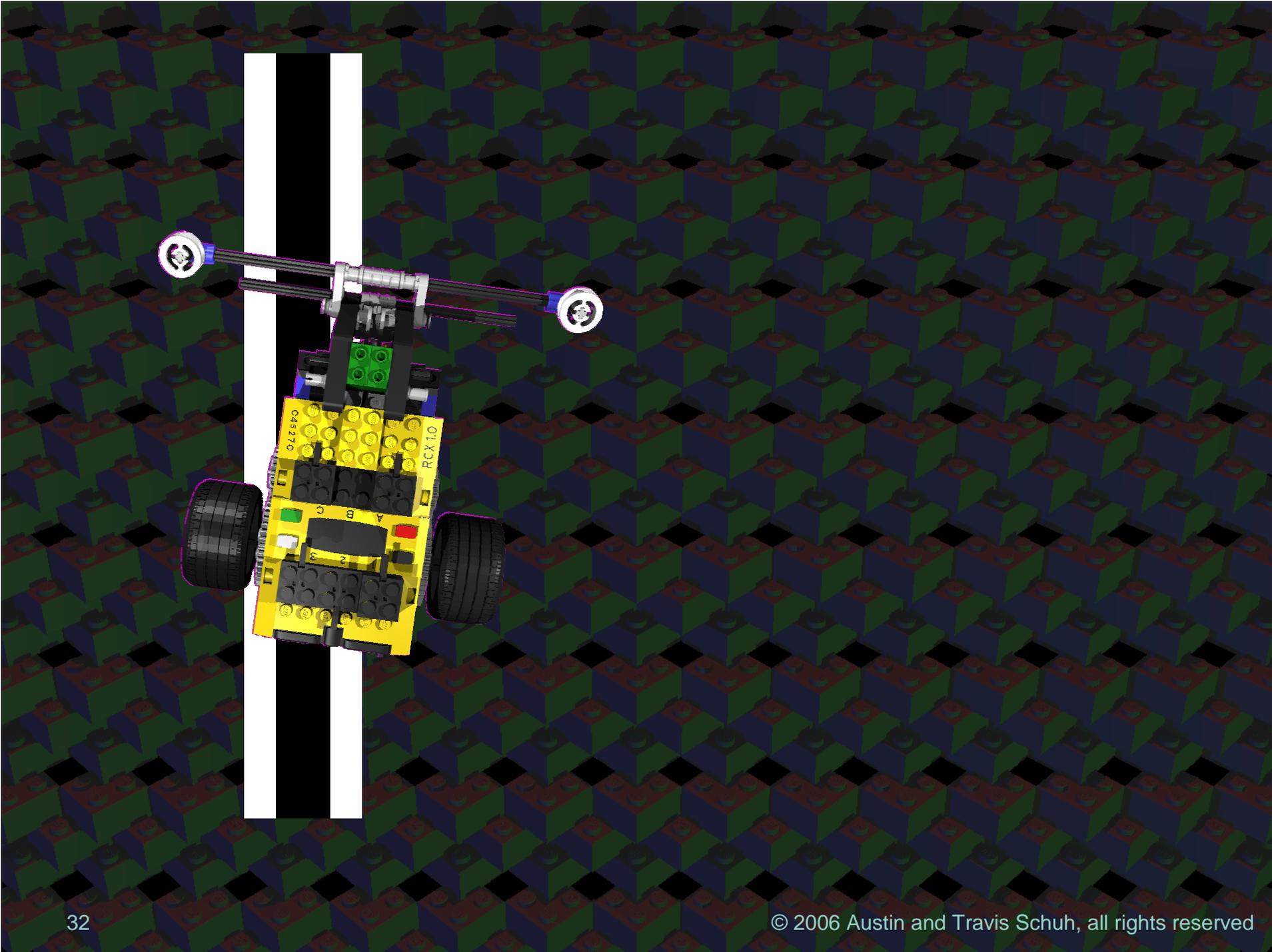


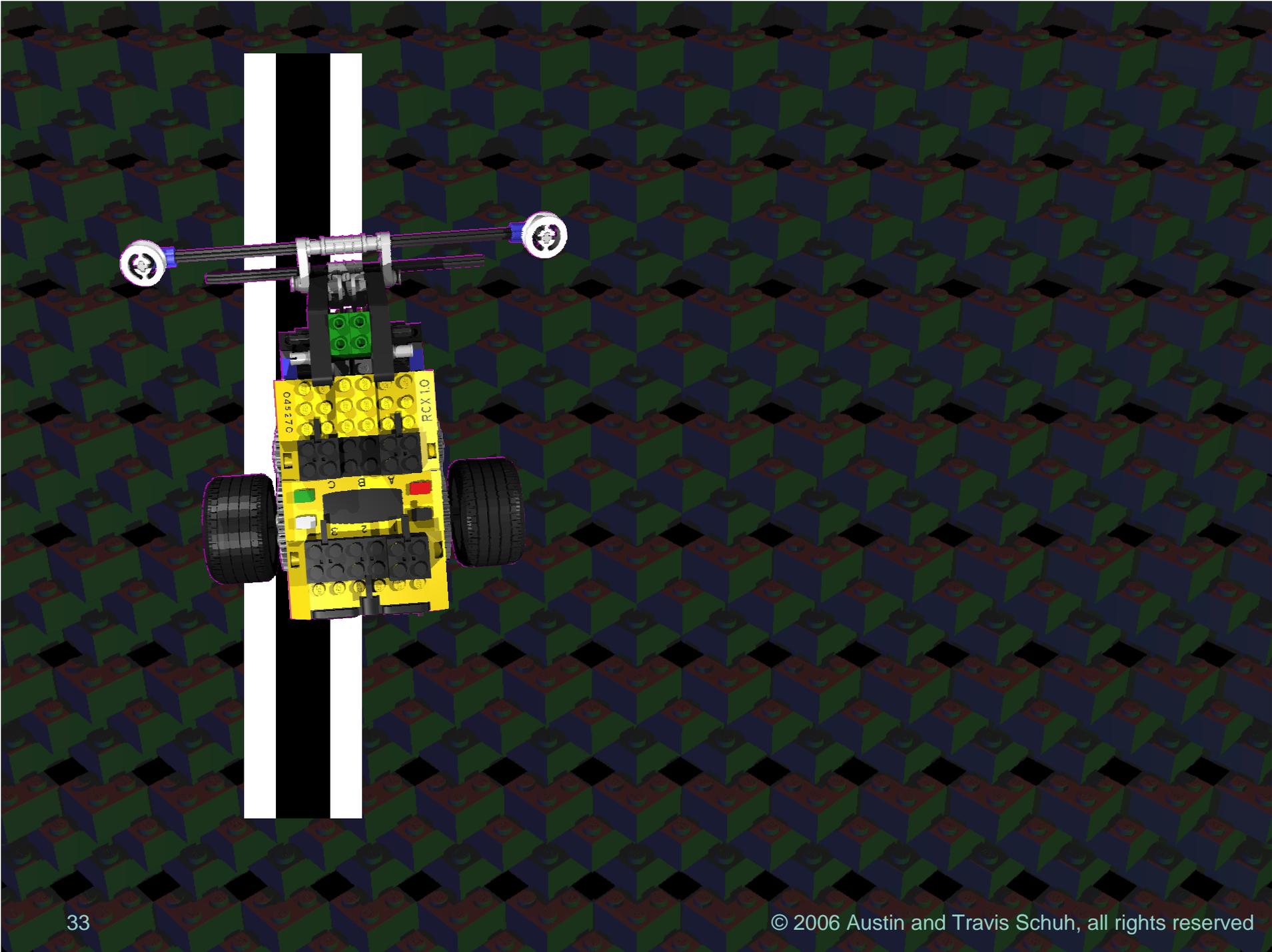


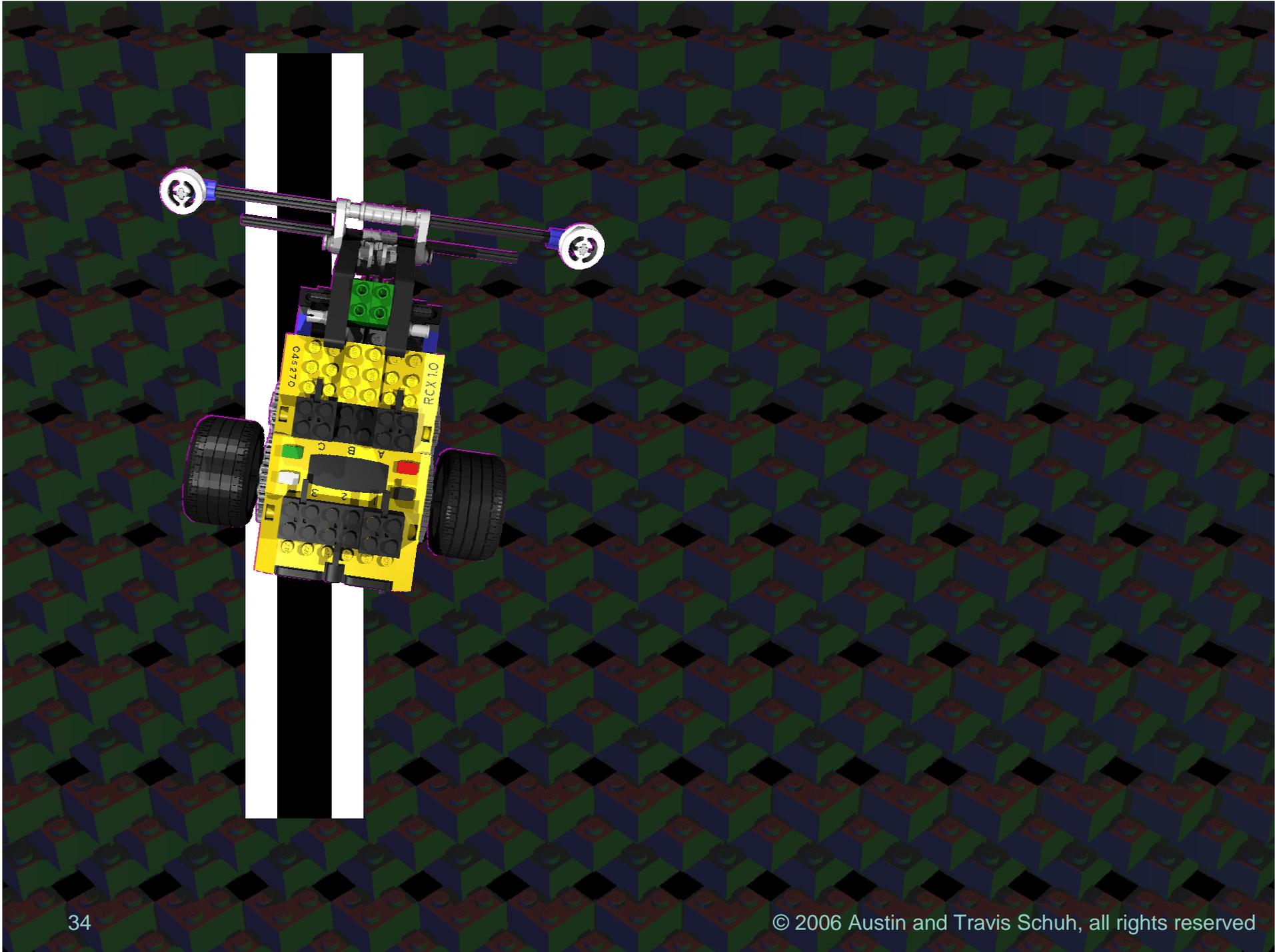


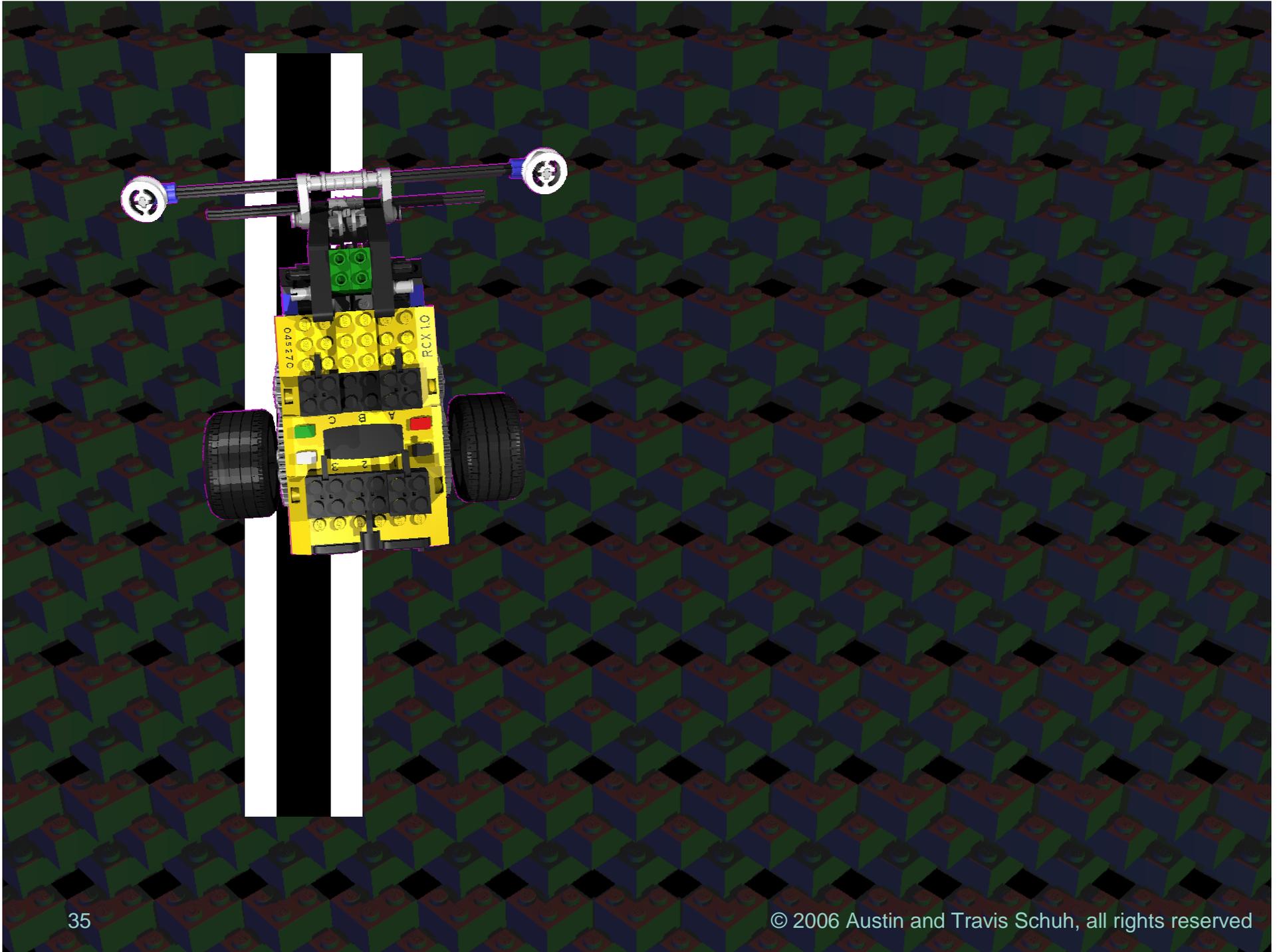


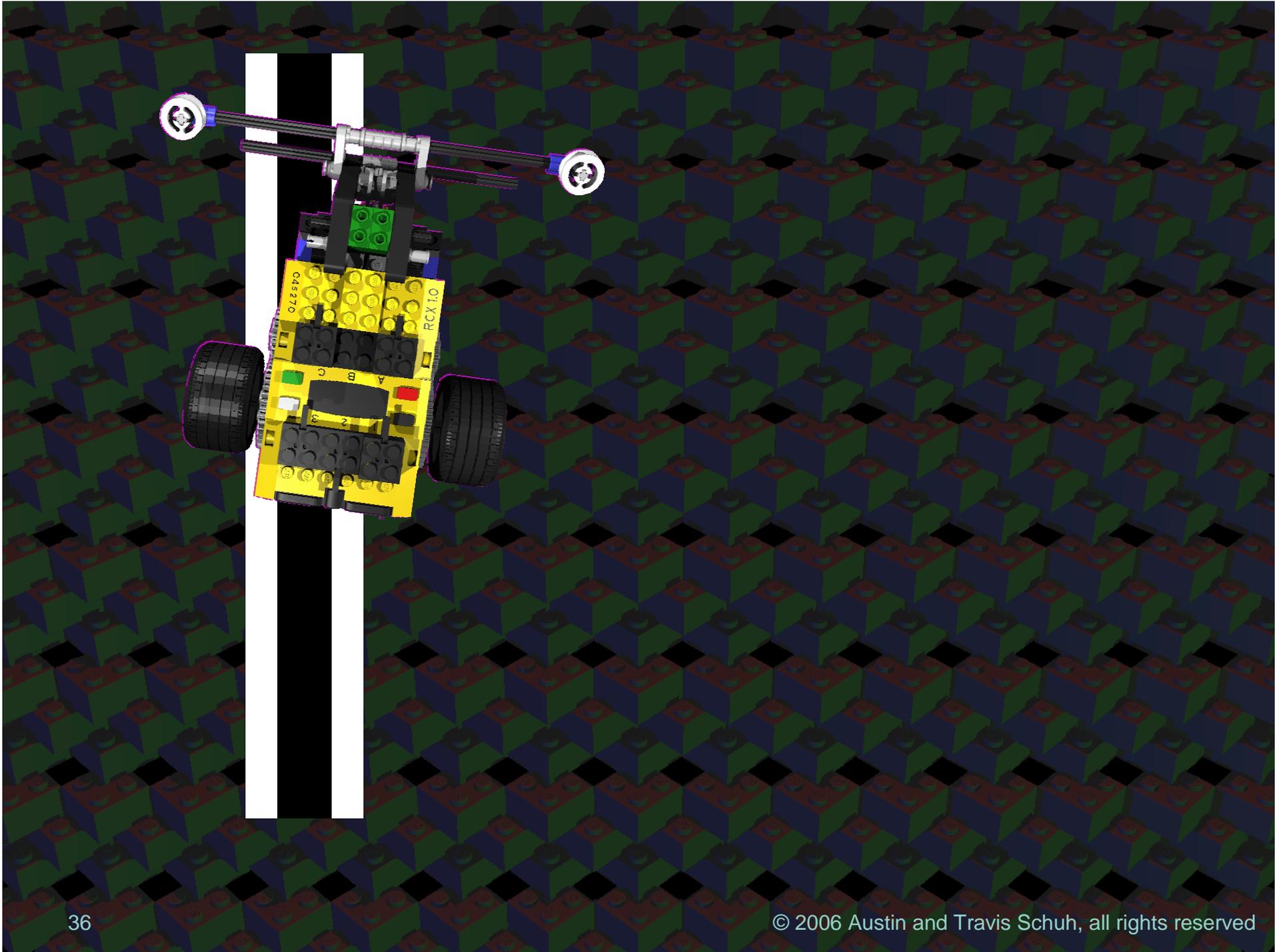


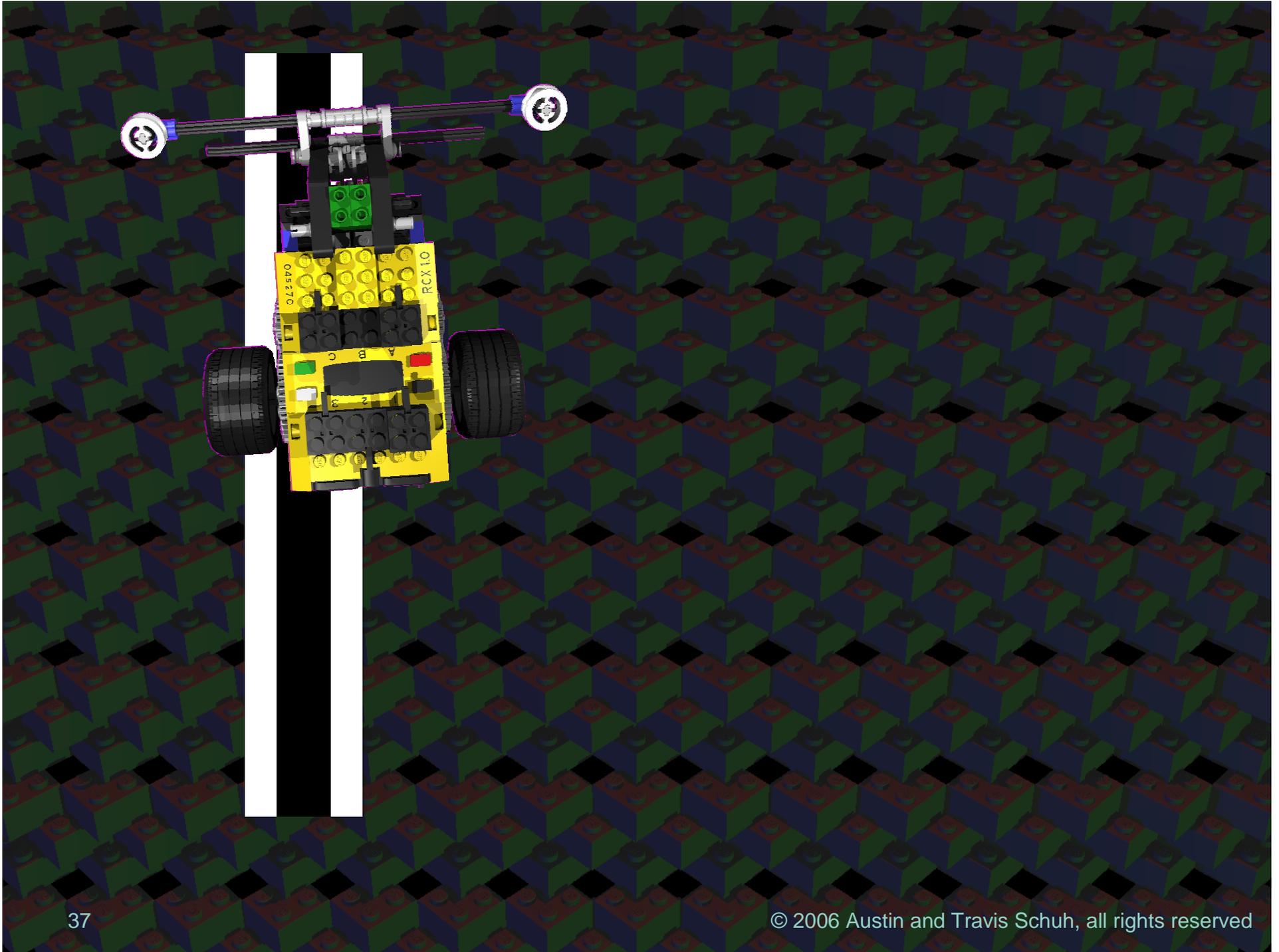


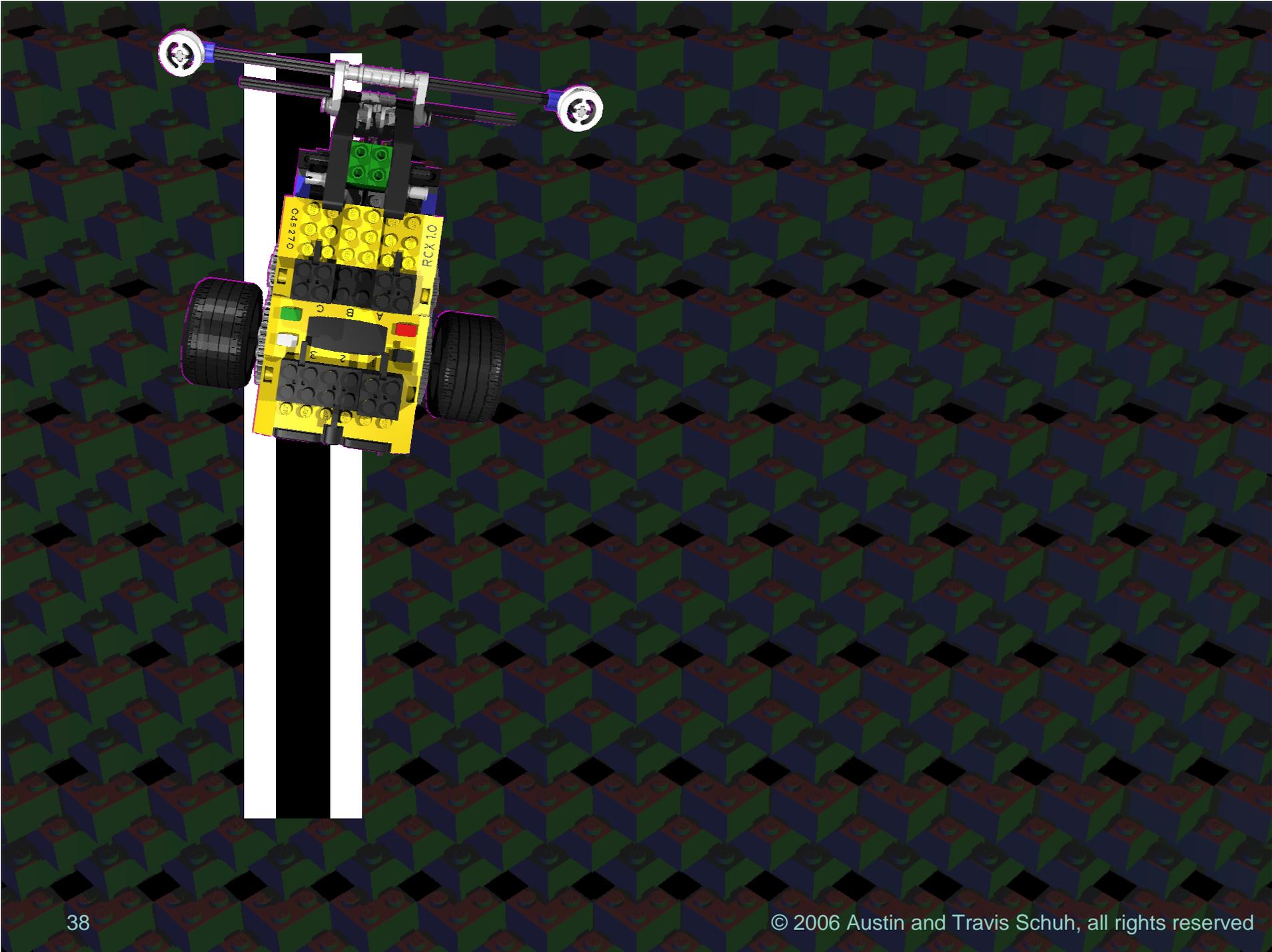


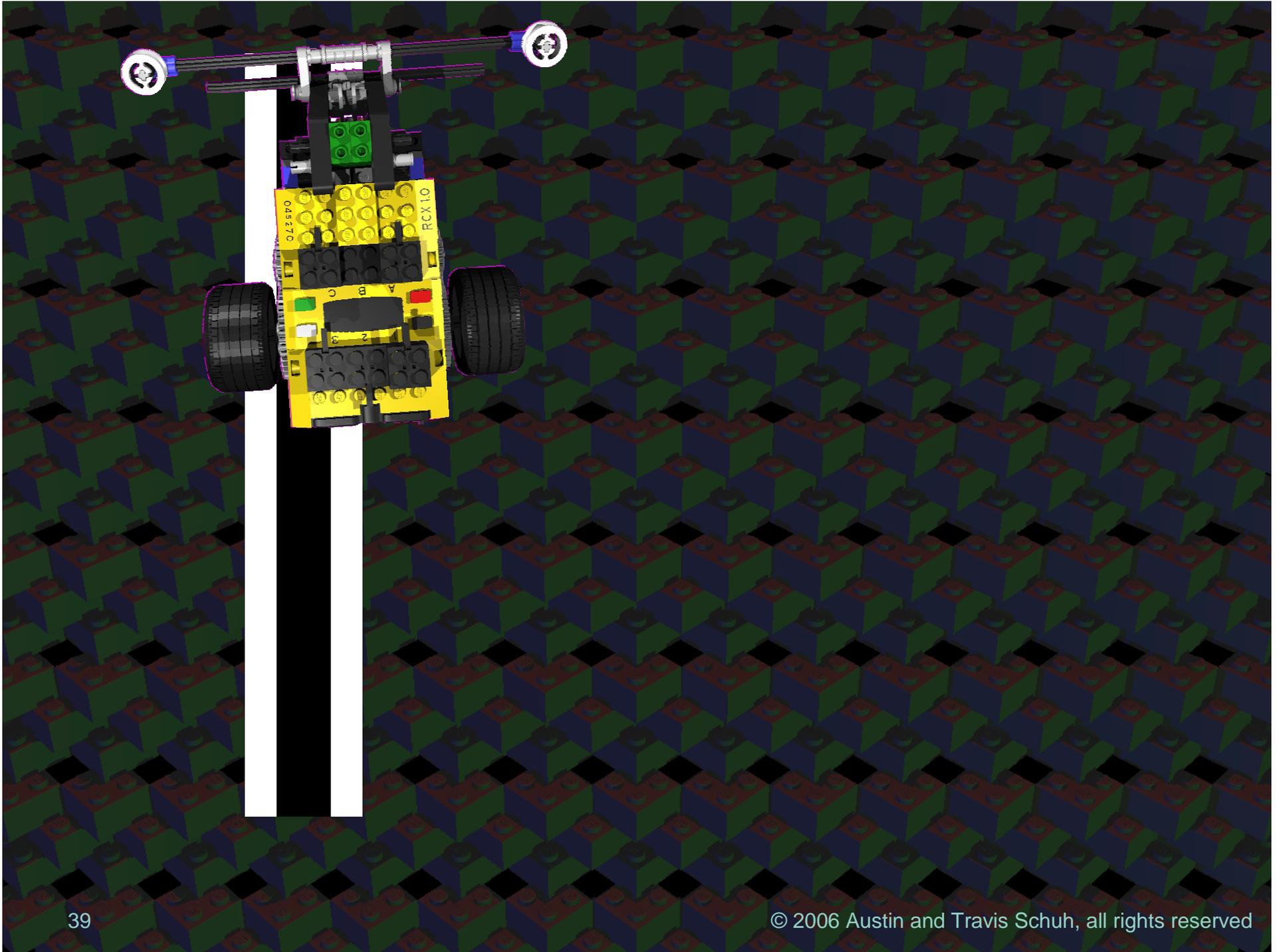












Things to do before and during the season

- Before the season, you should meet as a team to practice programming, building robot bases, and learning some of the limits of the robot kit.
- During the season, send Scott Evans, the game designer, any questions about game rulings that you view as stretching the rules, so that at the competitions, you can prove your strategy is legal.
- During the season, back up old versions of your code when you make major changes, like changing your approach to completing a mission.
- If your team needs any extra help, you can invite us to give our talk to your team. We will try to help you out if we have time to do so.

Simplicity often wins

- Many of the best robots are robots that are simple and can do their tasks reliably.
- This is a simple robot that had the highest score at the state competition in 2003.



Video of this robot in action is available at

<http://www.losaltosrobotics.org:8080/Main/FLL/Resources#06AT>

This is a complex robot that did quite well at the 2004 state competition.



Video of this robot in action is available at

<http://www.losaltosrobotics.org:8080/Main/FLL/Resources#06AT>



**Have a Great
Season!**