Robotic Perimeter

Subject Area(s) measurement, number & operations, technology

Associated Unit **None**

Associated Lesson **None**

Activity Title Robotic Perimeter

Image 1, [note position: centered]

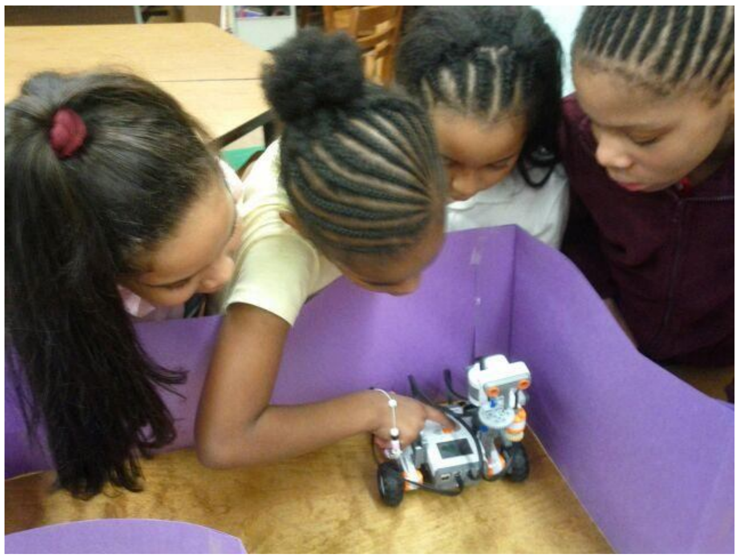

Image1

ADA Description: Students working with an NXT robot

Caption: Students use a wall-measuring robot to measure each side of a perimeter

Image file: students_wall-measuring_robot.jpg

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Grade Level 4 (3-5)

Activity Dependency N/A

Time Required 50 min

Group Size 2-5

Expendable Cost per Group US$0

Summary

In this activity students learn how to find the perimeter of a shape. Using a ruler, students measure model rooms made of construction paper. In addition they learn how they can use other tools such as a robot to help them take measurements, the ways in which this may be advantageous or disadvantageous, and discuss real world applications. Using a robot, built from a Lego NXT kit, that has been programmed to move alongside a wall and output the length of that wall, students note down the measurements found and

compare their findings for the perimeter found earlier. In both cases students also sketch a map of their area that is to scale, and labeled with the lengths found.

Engineering Connection

Mechanical engineers, computer scientists, electrical engineers, and other scientists often work together to create robots which will utilize sensors to explore and send back measurements of a space which either due to concerns related to safety or efficiency, it is not practical to manually measure or map. In addition, the trade-off between accuracy and error is a real concern that scientists grapple with no matter the experiment or tool being used.

Engineering Category = #1

Choose the category that best describes this activity's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

perimeter, Lego, sensors, robot, mapping

Educational Standards

ITEEA:
Standard 1, 3-5, D: Tools, materials and skills are used to make things and carry out tasks
Standard 3, 3-5, C: Various relationships exist between technology and other fields of study.
Standard 13, 3-5, E: Examine the trade-offs of using a product or system and decide when it could be used.
Standard 13, 6-8, I: Interpret and evaluate the accuracy of the information obtained and determine if it is useful

NYS Mathematics Core Curriculum 2005, Process and Content Performance Indicators Grade 4:
4.G.3 Find Perimeter of polygons by adding sides
4.M.2 Use a ruler to measure to the nearest standard unit
4.CM.4 Organize and accurately label work

Pre-Requisite Knowledge

Students must know how to add and draw a representation of a space, to scale, on a grid.

Learning Objectives

After this activity, students should be able to:

- Given a shape or area, find the perimeter.
- Be able to identify and describe possible sources of error, such as machine and human error.

Materials List

Each group needs:

- A model room or shape to measure each side of, and for the robot to navigate around and measure. This can be constructed using construction paper.
- An NXT robot constructed with one ultrasonic sensor pointed forward and one ultrasonic sensor pointed to the left side of the robot, equipped with a program for wall-measuring.

To share with the entire class:

- None

Introduction / Motivation

There are many situations in which people might want to figure out how big an object or room is. For example, we may want to make sure all our furniture will fit into the room of a new house, or find out whether or not large items will fit into our car, or figure out whether a new computer will fit on our desk. One way to describe how big something is, is to find its perimeter. To find the perimeter we just measure each side of the object or space and add up our measurements. (Use props, such as some small object that can be measured, to better convey the message)

If we want to measure the sides of a small object or room it seems easy enough to grab a ruler or measuring tape and quickly find the measurements ourselves. However, there are situations in which engineers and scientists might be interested in finding the measurements of a space that is maybe not safe to measure themselves, or may be too big or time-consuming to measure with measuring tape. In this case, they would use other tools. One thing they may choose to design and build to help them with this task is a robot! Robots use sensors to get information about the space they are in, and they use programs to carry out tasks and use the information they find. One kind of robot engineers have researched is a mapping robot. This is an idea for a robot which can wander around an area without bumping into obstacles, and send back a map of what it has seen and even how big the space is, how long each of the walls are for example. How might this kind of robot be useful to other people and scientists? (Have a discussion with students.)

Imagine you're an archaeologist who has just discovered a hidden underground tomb! You want to explore it and figure out how big the rooms inside are, but it is very old and the caverns may collapse at any moment. Rather than risk lives, it may be a good idea to send a robot which will be able to send back measurements and a map.

Today we too will be using robots to help us measure small model rooms. As I've mentioned, robots use sensors to help them gather information about the world. Without these sensors robots would have no clue about what's going on outside and no way to learn new kinds of information, so it might bump into walls, go the wrong way, and have no way to tell you anything at all much less any information about how big a room is!

The robot we are using uses an ultrasonic sensor attached to the front to help it avoid running into walls. It uses a second ultrasonic sensor at it's side to help it notice if a wall ends or turns away even when no walls are blocking its front. It also has rotation sensors in its wheels that tell the robot how much the wheels have turned, and using these it is able to figure out how far it has moved. The robot moves along next to a wall, using the ultrasonic sensors to avoid bumping into walls and to stop in case a wall has ended, and it uses the rotation sensors to figure out how far it has moved. This is how the robot we are using can tell how long each wall is.

Vocabulary / Definitions

Word	Definition
Perimeter	The size of something as given by the distance around it.
Scale (drawing)	A drawing that shows a real object with accurate sizes except they have all been reduced or enlarged by a certain amount (called the scale).
Error	The difference between the approximate and exact value.

Procedure

Background

In order to complete this activity the teacher should be familiar with building using the Lego NXT kit and creating programs using the Lego Mindstorms NXT software.

Before the Activity

- Prepare four to five robot using the following instructions:
    - First assemble the Five-Minute Robot, a link to the instructions is provided in the reference section.
    - Secondly, assemble just the radar portion from the Radar instructions in the reference section (only steps 7 and 8), or simply find another way to attach the ultrasonic sensor to the front of the robot, facing forward.
      **Note: The radar's ability to rotate is not used in this activity but by using this design it is easy to change the program to accommodate any future expansions of this activity.
    - Assemble the two pieces, as well as the extra ultra-sonic sensor as shown in the following images.

Image 2, [note position: centered]

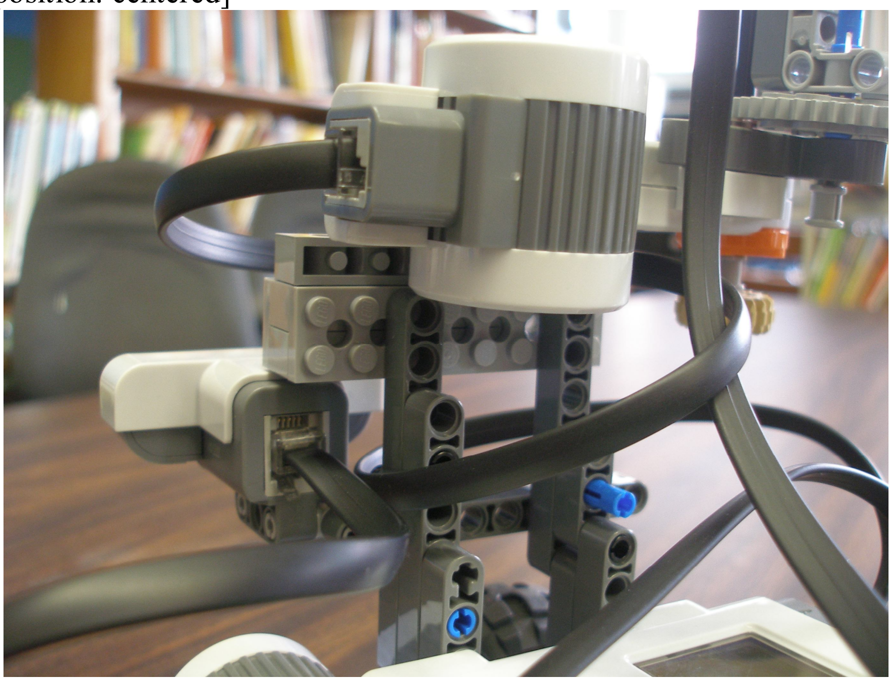

Image 2

ADA Description: Attaching the front-facing and side-sensor to the robot

Caption: This image shows one way to connect the sensors to the robot.

Image file: attaching_sensors.jpg

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Image 3, [note position: right justified]

Image 3
ADA Description: The fully-assembled robot.
Caption: none
Image file: wall_measuring_robot.jpg
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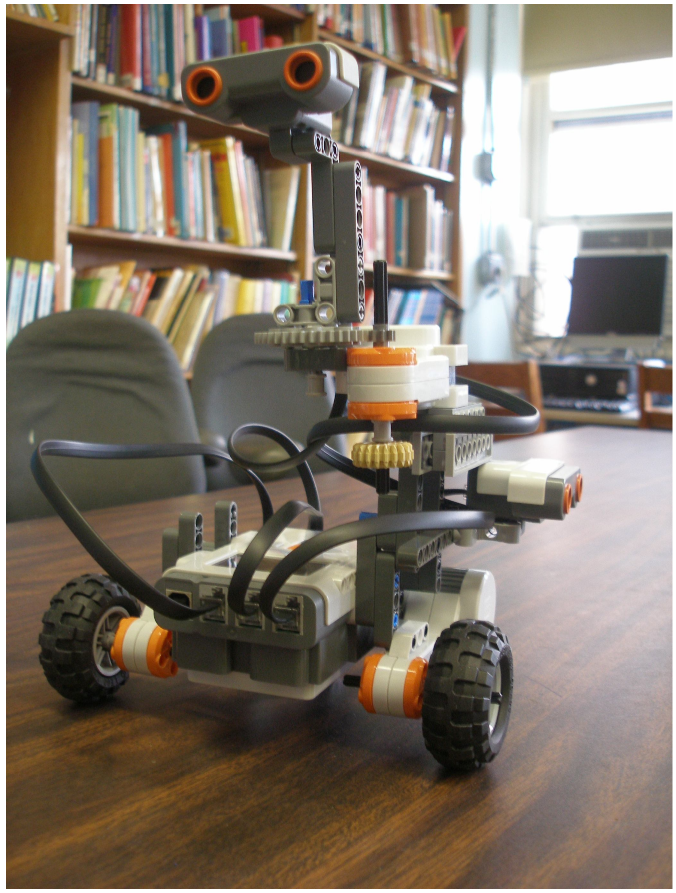


- Write and download a program to the robot such that:
    - The robot stops if either the side ultra-sonic sensor is too far from a wall (e.g. >4 inches) or if the front-facing ultra-sonic sensor is blocked by a wall (e.g. <4 inches).
    - Otherwise it moves forward.
    - Have the robot find and display the distance it has traveled to the NXT screen whenever it stops. To find the distance:
        - Use the number of rotations one of its wheels has taken, found by using the rotation sensor block for one of the motors being used by the robot. Then find the distance it has traveled by using the formula:
            - Number of wheel rotations x Wheel Circumference = Distance
            - Find the circumference of the wheel before using this formula, whether you use inches or centimeter will determine what units are being used to describe the distance being displayed.
    - After displaying the distance traveled wait for a button push and set the distance to 0 again before proceeding.
    - If the robot had stopped because the ultra-sonic sensor on the side was too far from the wall, have the robot turn left 90 degrees after displaying the distance it traveled
    - Otherwise turn right 90 degrees after displaying distance traveled
    - The robot might need to be repositioned before it can proceed so have it wait for a button press again.

- Put these instructions in a loop so that the robot will continuously check for the described actions and act accordingly.

- Prepare some model "rooms" for the students to measure. One option is to use heavy construction paper and glue or tape. Make sure that the walls are higher than the forward-facing ultra-sonic sensor, and note that for the particular program described, the assumption is that there are only 90 degree angles. If you would like to support more complex shapes, modify the program accordingly and make use of the front-facing sensor's ability to rotate to find the correct amount to turn. Also make sure that each wall is longer than the length of the robot so that it will have some space to turn and maneuver.

With the Students

1. Have the students measure each side of the room using their rulers and note down the measurements.
2. Have the students draw to scale the shape of the room as seen from above, labeling each of the sides of their drawing with the measurements they found.
3. Give each group a robot to use and explain the instructions for how to use it:
    a. The robot must begin with its side-facing sensor pointed toward a wall.
    b. Position the robot a few inches (2-3) away from the side of the wall, but parallel to the wall.
    c. Press the orange button to run the program
    d. The robot will move along a wall and stop as soon as it thinks the wall has ended
    e. Note down the measurement shown on its screen, this is how long the robot has measured the wall to be in inches (or centimeter if that was used in the program instead).
    f. Whenever you are done noting the measurement, press the orange button again and it will decide if it should turn left or right.
    g. Is it positioned correctly this time? If it's not, reposition the robot and then press the orange button again so it will continue on its way and measure the next wall.
    h. Sometimes a wall may take a few tries, especially if the robot was not positioned just right at the beginning or if the wall is a bit strange and confuses the sensor. Don't be afraid to cancel the program, and run it again to retry measuring a wall.
    i. If you had to make multiple attempts to measure a wall, note this down and be prepared to explain why, as well as why you think the robot may have been acting unexpectedly.
4. Have students draw another to scale drawing on a grid, this time using the measurements found by the robot, making sure to label each of the appropriate sides with the measurements the robot found.
5. Compare the two drawings and the measurements found.
6. Have a discussion with the students:
    a. Were the measurements the same?
    b. If not, why do they think this is?
        i. Some possible explanations:
            1. The sensors are not able to measure exactly but have some error ±3cm or more.
            2. The robot may not have accounted for its own length when measuring, but just measured how far it moved.
            3. The robot was moving along the inside of the wall, and could not travel as far as the actual length of the wall.
            4. The robot was confused by some other obstacles.
            5. The robot was not positioned correctly and so had to stop abruptly.
    c. How different are the measurements?
    d. Have a discussion about machine error on the part of the robot, as well as possible human error on the part of scientists and in this case, of the students, perhaps in positioning the

robot or of the teacher in the design of the walls, program, or robot. These are all things that can contribute to the differences between the measurements.

   i. Have the students subtract the measurements found for corresponding walls and discuss how big the differences really are.
   ii. Discuss and find percent error if the students have studied percentages, and division.

e. Did any of the groups have to try measuring with the robot multiple times? Why is that?
f. What other difficulties were there?
g. Now that we know the weaknesses and strengths of this robot, how else and in what other situations might it be useful to use this kind of robot?

Attachments

None

Safety Issues

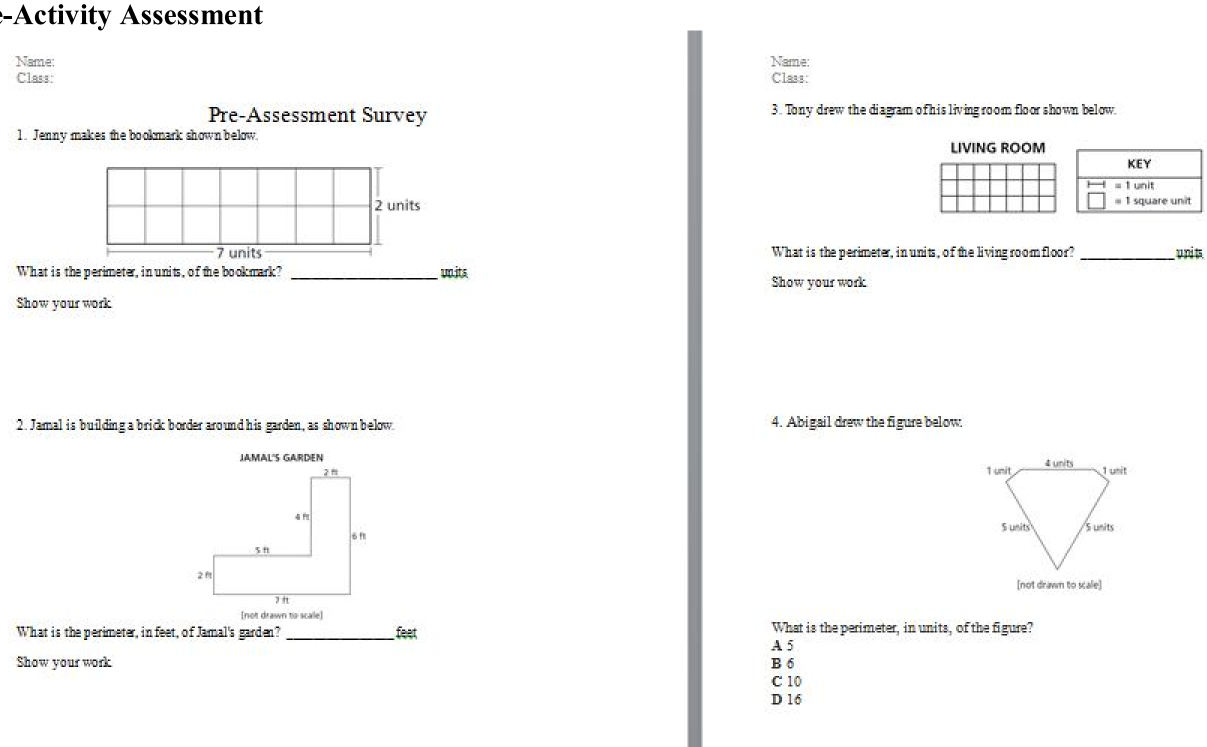
- None

Troubleshooting Tips

-Make sure all the motors and sensors are properly connected to the ports specified in the program

Assessment

Pre-Activity Assessment



Name:
Class:

Pre-Assessment Survey

1. Jenny makes the bookmark shown below.

What is the perimeter, in units, of the bookmark? ________________ units

Show your work

2. Jamal is building a brick border around his garden, as shown below.

What is the perimeter, in feet, of Jamal's garden? ____________ feet

Show your work

Name:
Class:

3. Tony drew the diagram of his living room floor shown below.

What is the perimeter, in units, of the living room floor? ___________ units

Show your work

4. Abigail drew the figure below.

What is the perimeter, in units, of the figure?

A 5
B 6
C 10
D 16

Figure 1

ADA Description: A pre-assessment administered prior to the activity.

Caption: Pre-Assessment

Image file name: robotic_perimeter_pre-assesment.jpg

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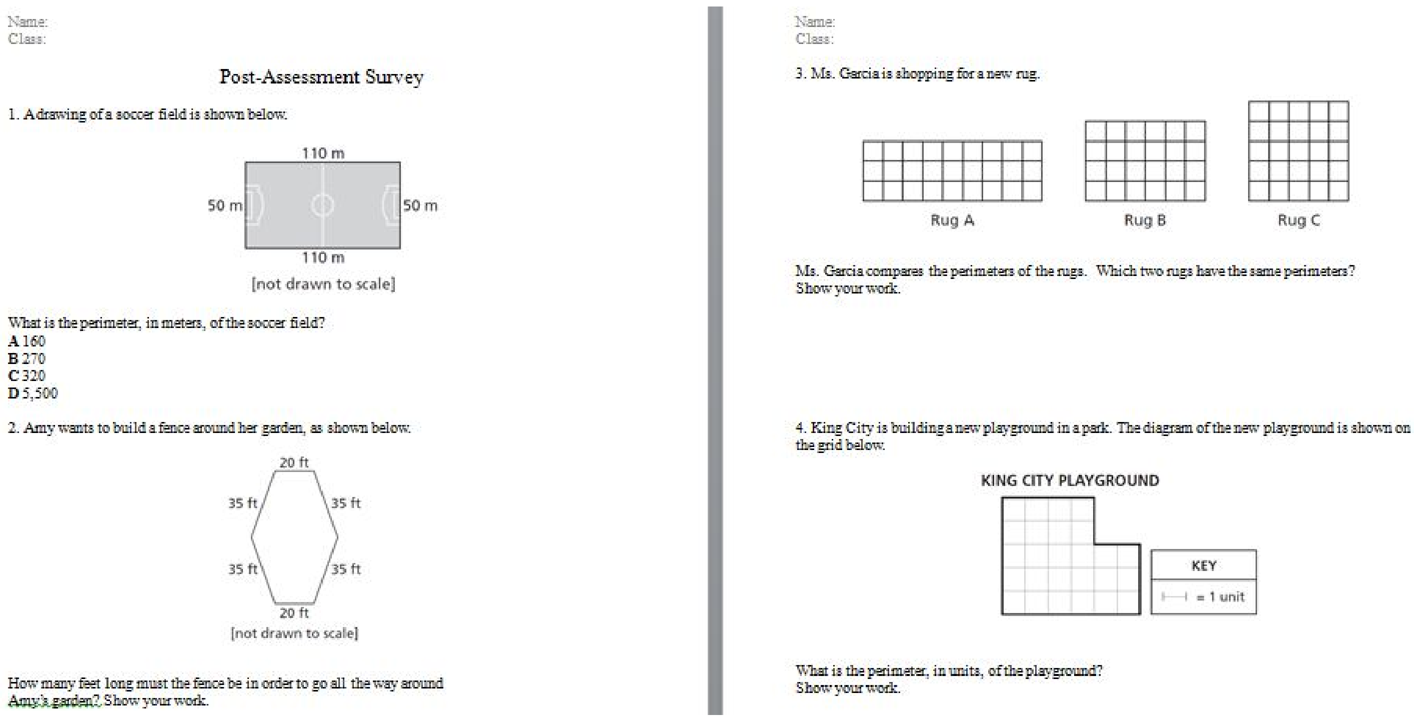
Post-Activity Assessment


Name:
Class:

Post-Assessment Survey

1. A drawing of a soccer field is shown below.

110 m
50 m
50 m
110 m
[not drawn to scale]

What is the perimeter, in meters, of the soccer field?
A 160
B 270
C 320
D 5,500

2. Amy wants to build a fence around her garden, as shown below.

20 ft
35 ft
35 ft
35 ft
35 ft
20 ft
[not drawn to scale]

How many feet long must the fence be in order to go all the way around Amy's garden? Show your work.

Name:
Class:

3. Ms. Garcia is shopping for a new rug.

Rug A
Rug B
Rug C

Ms. Garcia compares the perimeters of the rugs. Which two rugs have the same perimeters? Show your work.

4. King City is building a new playground in a park. The diagram of the new playground is shown on the grid below.

KING CITY PLAYGROUND
KEY
= 1 unit

What is the perimeter, in units, of the playground? Show your work.

Figure 2
ADA Description: A post-activity assessment.
Caption: Post-Assessment
Image file name: robotic_perimeter_post-assessment.jpg
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Activity Extensions

-Extend the activity and program to measure rooms of shapes that have angles other than 90 degrees.

Activity Scaling

- For lower grades, find the perimeter and focus on real-world robot examples in the discussion rather than on error.
- For upper grades, discuss percent error, discuss the design and programming of the robot as well as the mathematics used to find the distance. Ask students to design and program a robot for a slightly modified task or the same task with a modified design and with extra features.

Additional Multimedia Support

None

References

Five Minute Bot Instructions: http://www.nxtprograms.com/five_minute_bot/steps.html
Radar Instructions: http://www.nxtprograms.com/radar/steps.html

Other
None

Redirect URL
None

Contributors
Primary Developer: Rezwana Uddin

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Supporting Program

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