Super-Awesome Sylvia's
WaterColorBot!
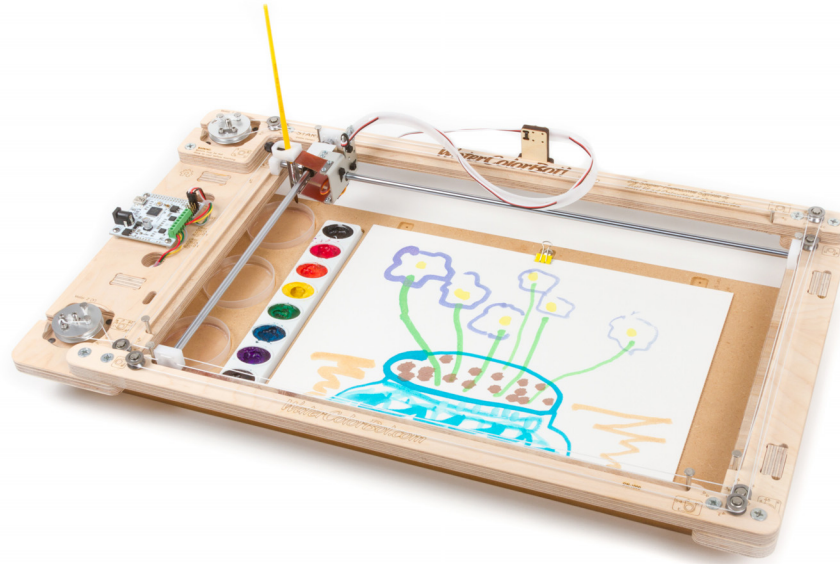
WaterColorBot v 2.0
Quick Start Guide

Evil Mad Scientist

Introduction: *The History of the WaterColorBot*

The **WaterColorBot** is a friendly art robot that moves a paintbrush to paint your digital artwork onto paper, using a set of watercolors. It was originally designed as a collaboration between "Super-Awesome" Sylvia Todd and Evil Mad Scientist Laboratories.

Sylvia with Lenore Edman and Windell Oskay, co-founders of Evil Mad Scientist Laboratories

Sylvia Todd, star of Sylvia's Super-Awesome Maker Show (available online at sylviashow.com), came up with the idea for the WaterColorBot because she wanted to create an art robot and enter it in the RoboGames competition. We had met Sylvia at Maker Faire in the previous few years, and she knew us from our EggBot and other kits and projects. She approached us at Evil Mad Scientist Laboratories about collaborating on the project, and we loved it.

Together we designed and built our first prototype in February 2013, and had a nicely-working robot about a month later. As we realized that this project had a lot of appeal beyond just a one-off project, we started developing it into a kit. Sylvia exhibited her prototype at RoboGames (and won a Silver medal), and we brought the WaterColorBot to Maker Faire, where thousands of people got to play with it. Sylvia was also invited to the White House Science Fair in April 2013, where she got to demonstrate the WaterColorBot for President Obama.

We launched the WaterColorBot on Kickstarter in July 2013, and the rest is (modern, recent) history. In November 2014, we released version 2.0 of the WaterColorBot, incorporating the lessons that we learned in the first year of making and using WaterColorBot. Version 2.0 features a refined chassis, and an all-new carriage for improved precision when plotting with pens.

What's in this guide?

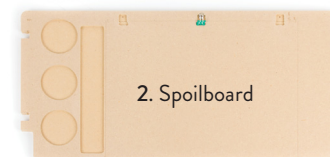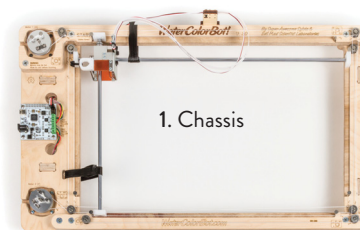This guide is here to help walk you through the first steps with your new WaterColorBot:

- Making sure that you've got everything
- WaterColorBot anatomy and principles
- Basics of using the WaterColorBot
- Basic maintenance and troubleshooting
- Additional tips, tricks, and resources for WaterColorBot.

Part 1: *Checking out your WaterColorBot*
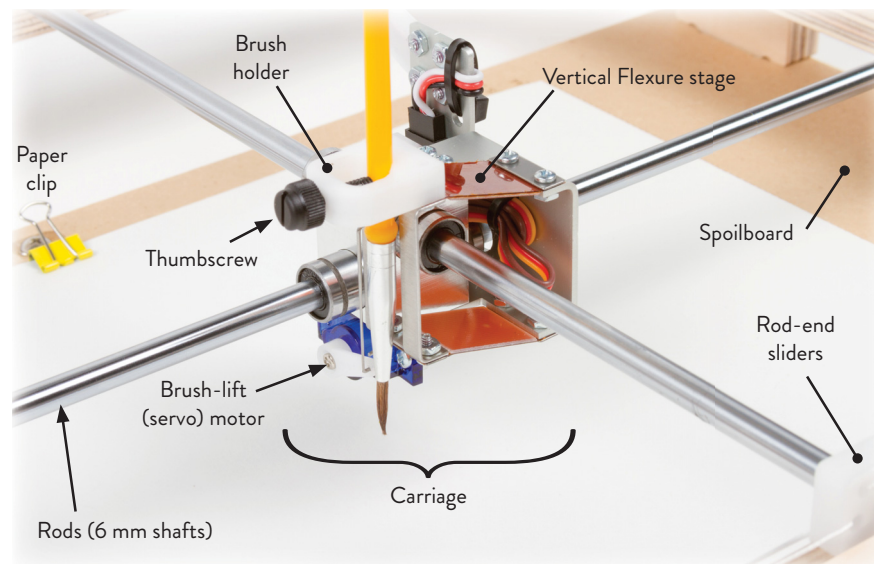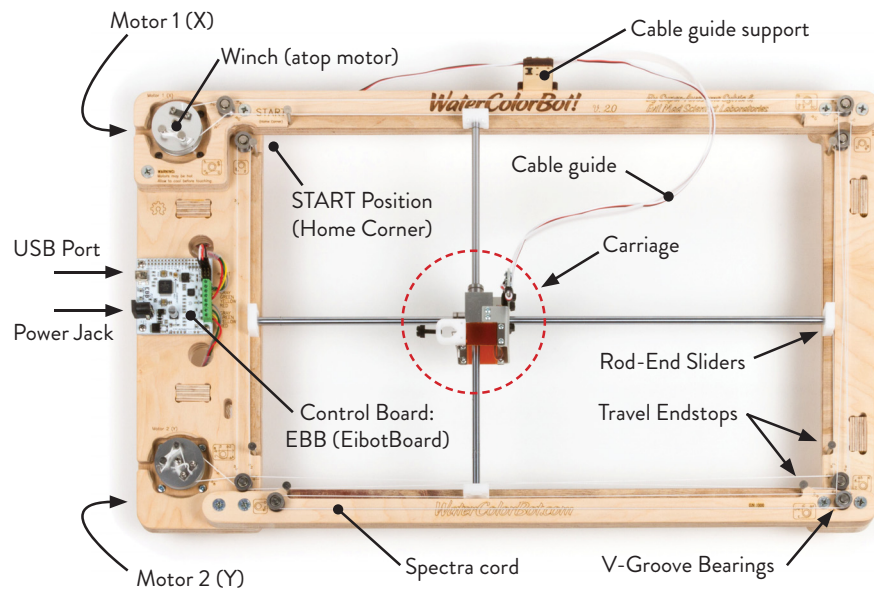
1.1 Kit Contents

Here are the parts that come with WaterColorBot 2.0:

☐ **1**. WaterColorBot Chassis (upper deck), pre-fitted with controller board, motors, winches, shafts, carriage, and stowage straps

☐ **2**. Spoilboard (the lower deck that holds paper, paints and water dishes), pre-fitted with a binder clip to hold paper

☐ **3**. Power Supply (9V, universal input)

☐ **4**. USB cable ("A to mini-B" type)

☐ **5**. Paint set with brush

☐ **6**. Petri dishes, plastic (3)

☐ **7**. Beaker, plastic, 50 mL

☐ **8**. Water dropper, plastic

☐ **9**. Hex L-wrench, 3/32"

☐ **10**. Binder clip and screw (extra)

☐ **11**. Watercolor paper, 9×12" (5 sheets)

☐ **12**. Sandpaper square (in envelope) *Not otherwise required, but if you happen to find an unexpected rough edge on one of the wooden parts, this could be helpful.*

1. Chassis

2. Spoilboard

3. Power supply

4. USB cable

6. Petri Dishes　7. Beaker

8. Dropper

5. Paints

11. Watercolor paper
12. Sandpaper

9. L-wrench

10. Clip and screw

1.2 WaterColorBot Anatomy

Let's take a brief look at what the different parts of the machine are called. We'll refer to many of these parts in the instructions, so it is helpful to know what's what.

Motor 1 (X)
Winch (atop motor)
Cable guide support
Cable guide
START Position (Home Corner)
Carriage
USB Port
Power Jack
Control Board: EBB (EibotBoard)
Rod-End Sliders
Travel Endstops
Spectra cord
V-Groove Bearings
Motor 2 (Y)

Brush holder
Vertical Flexure stage
Paper clip
Thumbscrew
Spoilboard
Brush-lift (servo) motor
Rod-end sliders
Rods (6 mm shafts)
Carriage

Part 2: *Quick Start / Overview*

In brief, here are the steps to getting started with WaterColorBot 2.0:

1) Install WaterColorBot software.
2) Preflight checks: Remove stowage straps. Make sure that carriage moves smoothly.
3) Move the carriage by hand to the START (home corner; upper left) position.
4) Set up desired media on spoilboard. For example,
   • When painting with watercolors: Paper, a paint palette, and water dishes
   • When sketching with a felt-tip pen: Paper alone
   • When using a dip pen: Paper and one well of ink
5) Connect power and USB cables.
6) Insert the brush into the brush holder, and check its height.
   In this context, the term "brush" means *the object mounted in the brush holder*. You can use essentially any tool or writing implement that (a) fits in the brush holder, (b) doesn't weigh too much, and (c) doesn't require substantial downward pressure. Yes, you can use literal paintbrushes, but also pens and pencils, and perhaps (with some experimentation) a conductive ink pen, laser module, hot wax pen (for batik), tube dispensing frosting or adhesives, a vacuum pick-up tool, stylus for your tablet, or something entirely different. But for brevity, we simply use the term "brush."
7) Open or create the artwork that you would like to print, and begin painting from within the software.

Part 3 of this guide goes through the first item on the list: The different software options for WaterColorBot. Part 4 goes through the "preflight check," and Part 5 goes through the rest of setup. It is followed by a sections on troubleshooting and tips and tricks for using your WaterColorBot.

Part 3: *Software*

### 3.1 Overview and Installation

Before you can actually begin using your WaterColorBot, you will need to download and install software.

There are three main programs that we use to control the WaterColorBot, each of which has unique advantages.
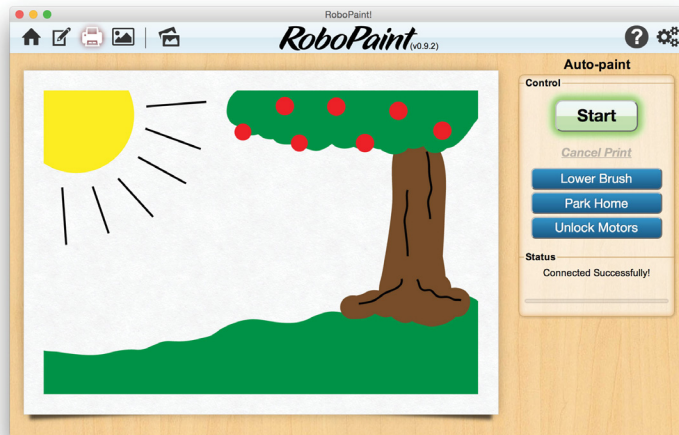

In what follows, we will introduce the different programs and interfaces. For interested developers and hackers, we'll also mention what's "under the hood" of each one.

All of our software is free to download, cross platform, and open-source in nature. For current software download links and instructions, please visit:

http://watercolorbot.com/software
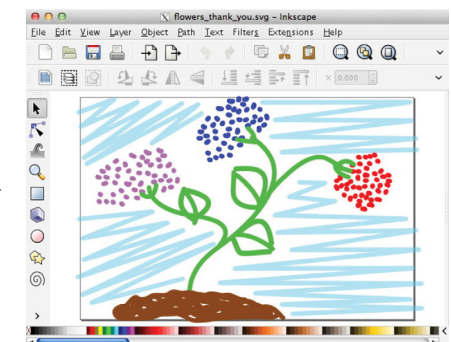
3.2 RoboPaint

Robopaint is a dedicated application for driving the WaterColorBot. In it, you can you can open existing vector artwork in SVG format, snap the colors to your paint palette, and paint the document. It also has a rudimentary edit mode that lets you create new drawings to print, as well as a short menu of sample drawings to try out.

If you're starting with existing SVG artwork, RoboPaint is generally the best of the three programs to use for a few different reasons. Most importantly, it can automatically fill in large solid regions of a painting with various textures. Options allow you to use paints or pens, and fine tune many parameters of how it prints. That said, it tends to err on the side of being simple to use, rather than necessarily providing the highest degree of control.

We recommend that all WaterColorBot users download and install RoboPaint. Windows users in particular should download and install RoboPaint prior to the other programs, as it also installs the WaterColorBot's USB driver.
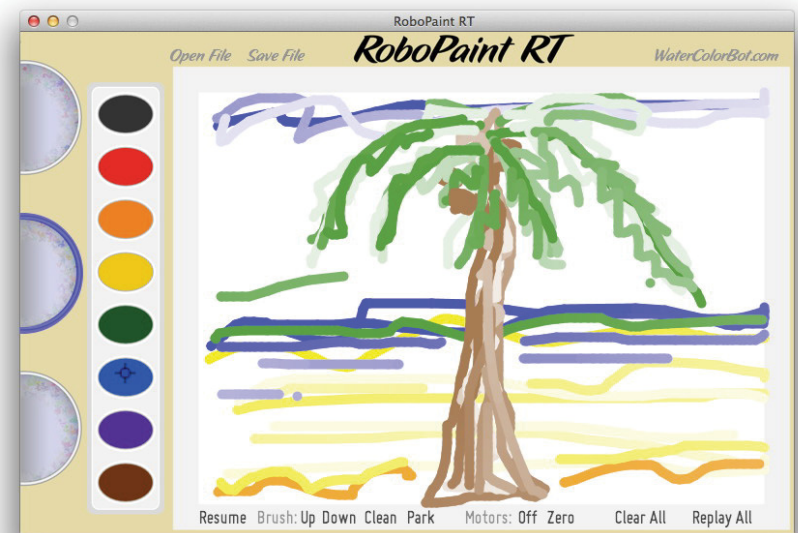

Skill Level: Novice to Intermediate
Level of control: Very automatic
Under the hood: Javascript, plus the WaterColorBot's API
Recommended for: All users

3.3 RoboPaint RT

Robopaint RT is a independent "real time" application that allows you to paint with the WaterColorBot. It's straightforward and manual: Click on a color in the paint palette to change to that color, click on the water to dip the brush in the water, and drag the brush to paint on your paper.

With RoboPaint RT, you can also replay your drawing to make multiple copies, and save the file (in its own format) to open up and print again later by replaying your actions. This program can be a lot of fun to play with and is a great way to get acquainted with the WaterColorBot, or to manually test out different things on the WaterColorBot without creating any digital artwork first. For those with good artistic skill, it can also be a remarkably powerful program.

There is also a separate version of the program, **RoboPaint RT BB**, originally designed for use with a Buddha Board water-painting surface. It does away with the color palette, and uses only the water dish. However, it can equally be used with a single well of ink, for example with a dip pen or with a brush for Chinese calligraphy.
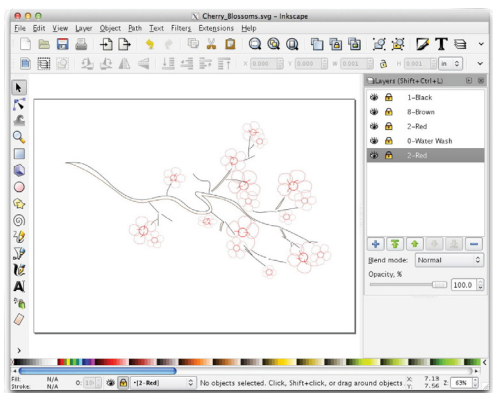
Skill Level: Novice to Expert
Level of control: Very manual
Under the hood: Java, in Processing
Note: Requires a recent version of Java on your computer
**Recommended for:** Artists, beginners, younger audiences, hands-on demos

3.4 Inkscape, with WaterColorBot Extensions for Inkscape

Inkscape is a superb, free vector graphics editor, for which we have written an extension (a plugin) that directly controls the WaterColorBot.

Our extension provides a fine grain level of control over exactly what will be painted, but more-or-less requires that you create the artwork within Inkscape to take full advantage of the features. For example, *layers* within a drawing are used to indicate which parts of the drawing will be painted with which colors. You can read much more about that process in our online documentation: http://watercolorbot.com/software

Inkscape itself (even ignoring the WaterColorBot extensions) is also capable of importing artwork in various vector graphics formats, as well as PDF (and tracing bitmap graphics to some extent). You can use it to create or edit SVG graphics that you can then open in RoboPaint

Users who have experience with the EggBot (and its Inkscape based driver) may wish to start with this Inkscape and the WaterColorBot extensions, before trying the other interfaces.
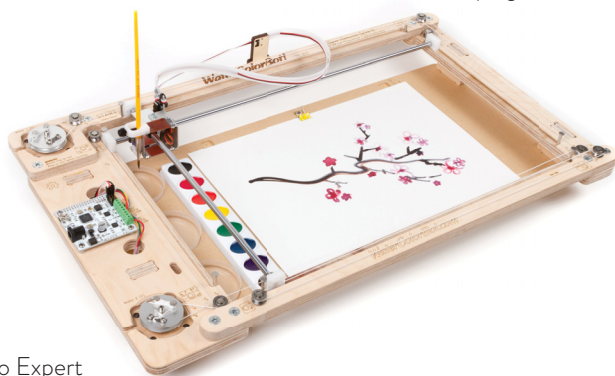
Skill Level: Intermediate to Expert
Level of control: Very high
Under the hood: Python (for the WaterColorBot extensions)
Note: Requires you to install Inkscape. Mac users will also need to install XQuartz.
Recommended for: Artists, hackers, those seeking a finer level of control. RoboPaint users who need a more powerful tool for importing, creating, or editing vector graphics.
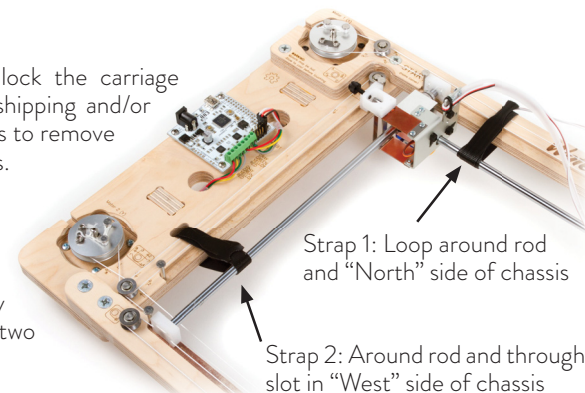
Part 4: *Preflight Checks*

4.1 Overview

Before operating the WaterColorBot 2.0 on a given day, take a moment to give the machine a once-over to make sure that everything is working properly. Doing so will improve the performance of the machine and prolong its life, as well as avoid several potential sources of frustration.
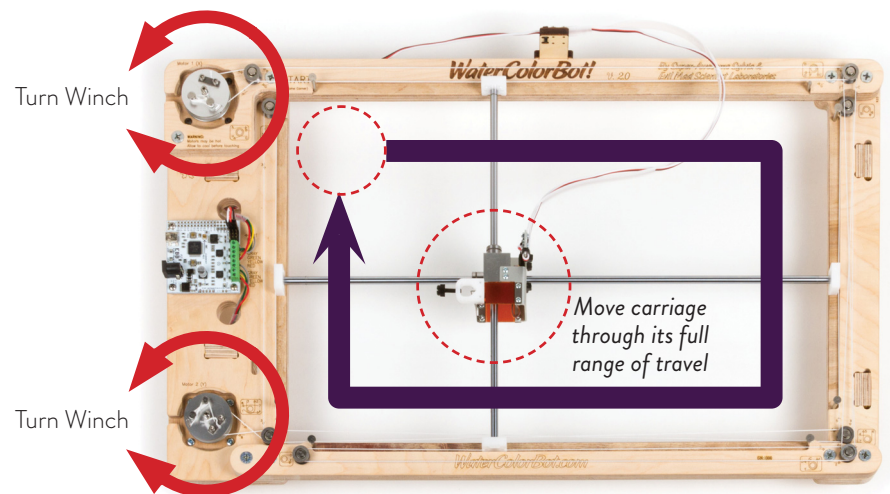
4.2 Stowage Straps

Two reusable velcro straps lock the carriage in the home corner during shipping and/or storage. The first setup step is to remove and set aside these two straps.

When packing up again, dis-connect from power and move the carriage to the home corner. Then, gently but securely, re-apply the two straps in the locations shown.

Strap 1: Loop around rod and "North" side of chassis

Strap 2: Around rod and through slot in "West" side of chassis

4.3 Test the Drive System

Turn Winch

Move carriage through its full range of travel

Turn Winch

The "real" preflight check is to try out the drive system and make sure that everything is working properly. With power still disconnected, turn the winches by hand to move the carriage once through its range of travel– all the way to the far corner and back. The mechanism works (and feels) like an Etch A Sketch. If everything is set up correctly, the carriage should move smoothly there and back, without requiring excessive force.

This routine serves a couple of purposes. First, it gets all the parts moving – pulleys and bearings and all –to overcome any stiffness in the joints after sitting still for a while. More importantly, it serves as an overall diagnostic and health check for the machine. If the

carriage moves consistently and smoothly when you turn the winches by hand, it will also move consistently and smoothly under computer control. On the other hand, if the winches or carriage cannot be moved by hand, then the motors on the WaterColorBot will not be able to move them either. (And, it is much better to discover issues here in the setup process than in the middle of a painting.)

Here are some additional things to watch for during the preflight:
• Make sure that the four rod-end sliders ride in their grooves.
• Make sure that the two rods are "square" to the frame. You can check this with the carriage in the home corner: All four rod-end sliders should rest against their endstops.
• Watch for "slop" in the motion: Extra slack in the Spectra cord can cause the cord to droop as the winches turn, with a corresponding loss of precision.

If you encounter any issues during the preflight, please see §6, Maintenance and Troubleshooting.

Part 5: *Basics of Using the WaterColorBot*

5.1 The Home Corner
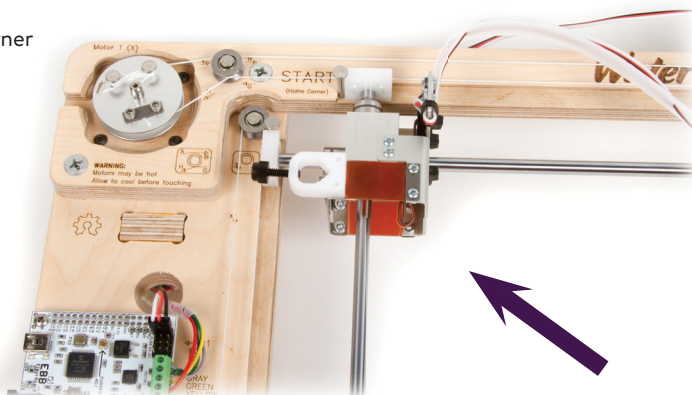
Before running the WaterColorBot, always position the carriage in the aptly-named START (Home Corner) position: As far to the left, and as far back as it will go.

When automatically painting, the carriage will normally return to this position when the painting is complete, leaving it ready for the next painting. In some cases, you may need to use the "Park" (AKA "Move Home") command to send the carriage back to its home position.

If you need to move the carriage by hand (for example, before your first painting), make sure to turn off the motors first, so that you are not forcing them under power. You can either physically unplug the WaterColorBot from power or use software to turn off only the motors. (The software command to do so may read as "unlock motors" or "turn off motors.")

5.2 The Spoilboard
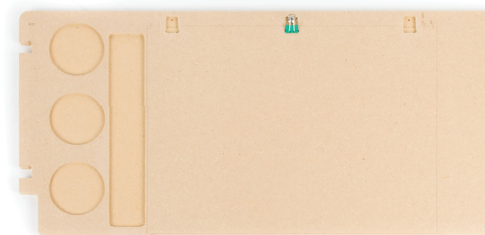
The "spoilboard" is the lower deck of the WaterColorBot, which holds the paint palette, water dishes, and the paper.

The standard-issue spoilboard is made of MDF (fiberboard), and is designed to hold paper with one or more clips. It has engraved marks to help you center the paper.

The paint set indexes into the long slot. When using the standard Crayola paint set, orient black at the top and brown at the bottom.

There are 3 round recesses, to fit the little water dishes. Always install all 3 dishes. The water dishes are the lids (the shallow, larger diameter halves) of the plastic petri dishes. They are made of washable plastic.

The small plastic beaker is also made of washable plastic. It has three little spouts, and is very helpful for pouring water into the dishes.

When you pour water into the dishes, fill them only about halfway, to help avoid splashing and spilling.

The paper is normally held in place by a single binder clip in the center. You can also hold down the paper by other traditional means, such as with masking tape.
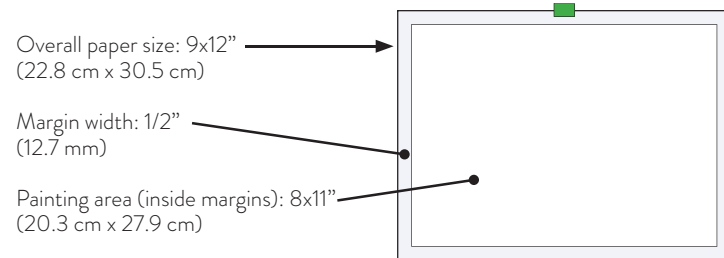
An extra clip and screw (#10 from §1.1) are provided in case you would prefer to hold down your paper with clips in the left and right positions instead of center. (That gives more "rigidity," but it is harder to insert and remove the paper.)

The WaterColorBot is designed to fit 9x12" watercolor paper (one of the most common sizes), and to paint up to within 1/2" of the edges.

Overall paper size: 9x12"
(22.8 cm x 30.5 cm)

Margin width: 1/2"
(12.7 mm)

Painting area (inside margins): 8x11"
(20.3 cm x 27.9 cm)

To use US Letter or A4 paper sizes— both are a little smaller than 9x12" —align the paper to the top, and center it, using the marks provided on the spoilboard.

The chassis of the WaterColorBot indexes into the spoilboard with its feet. This "upper frame" is removable for easy access to paint, water, and paper.

When removing the upper frame from the spoilboard, take care to lift it directly upwards, so that it comes off cleanly, without spilling your water or paints.
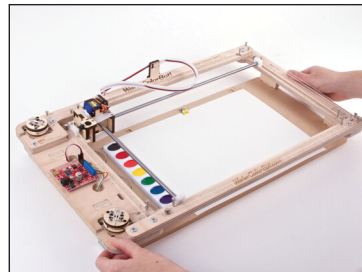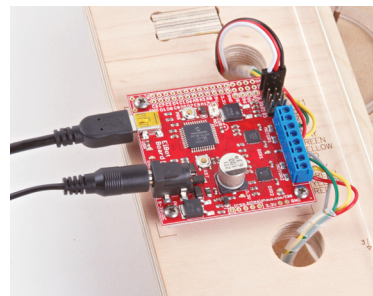
5.3 USB and Power

The WaterColorBot comes with a universal-input power supply that takes worldwide voltage (although it will need a plug-shape adapter in some countries).

It also comes with a USB cable to connect to your computer.

If your computer is running Windows, install the RoboPaint software (§3.2) before hooking the WaterColorBot up to your computer.

5.4 Inserting the Brush and Setting the Height

The brush holder is located at the front-left corner of the carriage. The brush holder can fit any writing implement up to about 0.44", or 11.1 mm in diameter.

A black plastic thumbscrew holds the brush in place. (In the photo here, the "brush" is an art pen.)

To insert a brush, loosen the thumbscrew enough that the brush can fit through, lower the brush into place, and tighten the thumbscrew by hand.

Brush up

Brush down
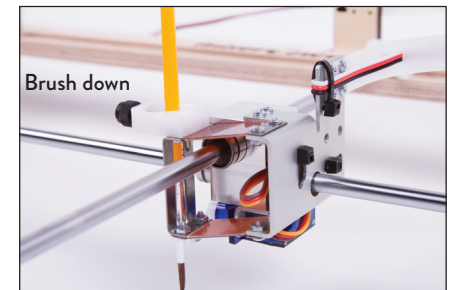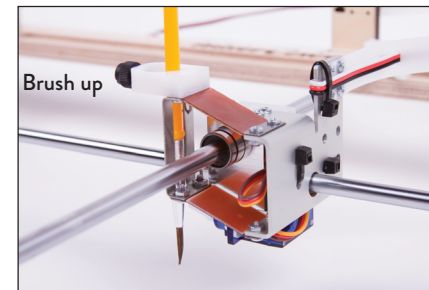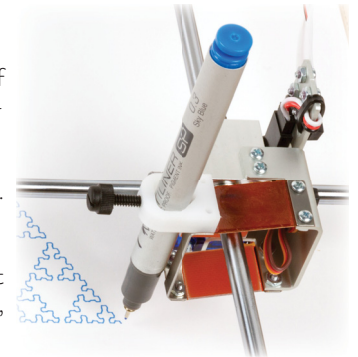
The brush moves up and down, driven by the little servo motor on the carriage.

In the "Brush Up" position, the brush must be high enough to clear the lip of the water dish, the top of the paint pans, and to travel over the paper without dragging. When down, it needs to be low enough to paint on the paper, dip into the water, and get paint from the palette. There is also usually a "Wash" position, lower than the Down position, for washing the brush in the water dish.

The best way to set the brush to the right height is to use the software to raise and lower the brush. Insert the brush by hand while the carriage is in the "brush down" position.

5.5 Summary: Basics of setting up the WaterColorBot for Use

1. Move the carriage, by hand, to the upper-left (Home) corner, marked START
2. Load your media (paper, paint set, water dishes) on the spoilboard as desired
3. Lower the upper frame (main chassis) of the WaterColorBot onto the spoilboard
4. Connect power and USB cables
5. Insert the brush and check the height
6. Begin painting from the software

When trying out the WaterColorBot for the very first time, we suggest printing the "Simple Face" example file, which you can find in the Examples menu of RoboPaint.

Before every subsequent print, make sure that the carriage is back in the Home Corner. And, if you need to move the carriage by hand, first make sure that the motors are off.

Part 6: *Maintenance and troubleshooting*

6.1 Overview

The WaterColorBot is designed to last for years of use with proper care. Using the stowage straps and performing the preflight check will help to prolong its life and to detect (and let you correct) issues before they become serious.

Little regular maintenance is needed. While the Spectra cord is strong (ten times stronger than steel by weight), it *can* gradually stretch, and you may on occasion need to take out a small amount of resulting slack from the cords.

6.2 Performance Issues

If the motors do not move but (1) everything looks correct, and (2) your computer doesn't report any errors, triple check that the 9 V power supply is plugged into a working outlet.

If the winches do not turn easily in the preflight, the first check is to see if the two rods are square to the chassis, for example by looking to see if all four rod-end sliders are up against their stops when the carriage is in the home corner. If they are not, you may need to slightly reposition the rod end sliders on the cord.

If the carriage loses its position (e.g., does not return home properly), "crashes" into the wall, or makes "cogging" noises when the motor skips steps, then return to the preflight condition with motors off, and see if you can identify the issue.

Extra slack in the Spectra cord, or "slop", can cause the cord to droop as the winches turn. That can degrade print quality (since small motions of the winch will not necessarily translate into movements of the carriage), cause the cord to fall out of the V-groove bearings, or in some rarer cases create a "knot" that cause binding in the Spectra cord as the winches turn. Catching and correcting minor slack early can prevent these more serious issues.

In extreme cases of knotting or binding where the carriage does not move smoothly, it may be necessary to re-lace the Spectra cord from scratch. Please consult our extended online instructions or contact support for guidance.

6.3 Taking out slack

It may be necessary on occasion to take out some slack from the cords. Experience with first-generation units has shown that a *properly configured* WaterColorBot will typically (if used regularly but not every day) go 3-6 months between adjustments, after its initial settling-in period. (WaterColorBot 2.0 comes assembled so that the initial settling-in period happens during factory testing and calibration.)

The procedure for taking out slack is as follows. With power off, move the carriage to the *lower right* position, diagonally opposite from the home corner. Use the two stowage straps – one each around each rod and a chassis side – to hold the carriage in that position. The cord is clamped atop the winch with a little metal plate (the "cord clamp"), held down by two screws. Loosen one screw and remove the other, to free the cord end. Unwind the cord from the two rivets atop the winch, so that you are left only with the cord itself, coming up through the hole in the winch top. Pull the cord through the hole until all of the slack in the system is removed. You will need to gently turn the winch counterclock-

wise (or at least prevent it from turning clockwise) in order to do so.

Loop the cord back and forth, as a figure 8, around the two rivets on the top of the winch, until nearly all of the loose cord is tied up between them. Guide the free end of the cord underneath the cord clamp, and rotate the cord clamp into place. Replace the second screw and tighten both screws to secure the cord in place. Take care that the loose end of the Spectra cord is short enough that it can't get caught in the winch as it winds.

6.4 Support Resources

In case of continued difficulty or an issue that we have not discussed, you may wish to read through our extended documentation and extensive troubleshooting guide (which can be found at watercolorbot.com/docs), post in our support forums, or contact support by e-mail. (See the last page of this guide for contact information and links.)

Part 7: *WaterColorBot Tips and Tricks*

7.1 Paint

• A high-end set of watercolor paints can cost hundreds of dollars. That said, there is more difference between a $5 Crayola paint set and a $20 Cotman set than there is between a $20 set and a $200 set. We recommend splurging on a $20 set, once in a while, if you're so inclined.

• When learning to use the WaterColorBot or giving demos, low-end watercolor paints (Crayola, Prang, etc) are generally the best choice. The online documentation for the WaterColorBot includes a guide to common paint sets.

• When your Crayola paint palette is empty, wash it out gently with cold water: it can be reused as a palette for tube-based watercolor paints.

7.2 Paper

• You can slide paper in and out, under the front of the chassis, without removing the upper chassis from the spoilboard.

• You can use smaller-yet paper (e.g., notecards) on the WaterColorBot, even if they don't fill up the spoilboard. Either affix it to a larger sheet of paper (9x12", US letter or A4) with masking tape, or to clip it above larger paper on the spoilboard.

• Other types of paper not intended for watercolor often work quite well. "Bristol board"

drawing paper is great for both pens and painting.

• Paper tends to warp as it gets wet, particularly with uneven wetting and lower grades of paper. Methods of dealing with this include pre-wetting and stretching paper, as well as holding paper down with tape or in blocks. Watercolor painting is an old art, and people have been solving these problems for hundreds of years; read up on the subject online or in books.

7.3 Painting Style

• Watercolor painting is unusual versus other painting techniques in that paint colors are frequently mixed on the paper, rather than in a palette. While there are only 8 colors in the palette, you can have a continuous range of colors in your completed painting.

• When making your drawings on the computer, exaggerate your motions to compensate for the way that a brush bends and flexes when painting. A square will have rounded corners. A small circle may end up as just a dot. When painting by hand you compensate naturally, since you watch the tip of the brush. But when asking a robot to paint for you, you may want to think about it in advance.

• You get very different effects and more paint mixing on the paper if your paint has more water in it. You can use the water dropper to add a drop of water to pre-wet your paint pans – which can have a dramatic effect on painting style.

• The WaterColorBot is not limited to working with watercolors, nor even to using a brush. Some of the WaterColorBot software interfaces provide options for regular pencils and pens, watercolor pencils, dip pens, and painting with water alone.

7.4 Storing and shipping the WaterColorBot

• The WaterColorBot comes in a sturdy, reinforced carrying case that is suitable for long-term use. For shipping, also use an external box that offers impact and scuff resistance.

• Make sure that the paint brush, spoilboard, water dishes, dropper, beaker, and paint set are *fully dry* before packing the WaterColorBot for long-term storage. Moisture can damage the wood, electronics, and other components in long-term storage.

• Remember to use the stowage straps (§4.2) when packing up the machine, to lock the carriage and rods in a stable configuration for storage. It is also recommended to lower the brush holder into the "pen down" position for storage.

Extensive online documentation
& resources for WaterColorBot:
watercolorbot.com/docs