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Hardware Article

Osmar, the open-source microsyringe autosampler

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ABSTRACT

Microsyringe manipulation is a common approach for the automated sampling of liquids or gases. Commercial devices with this capacity are typically priced above US$30,000, despite their technology being not clearly superior to that commonly found in low-cost (commonly less than US$1,000) devices controlled using G-code (3D printers, CNC routers and laser engravers, for example). Here, we present osmar, an open-source autosampler built by combining parts of two low-cost G-code machines. Movement precision was excellent (error < 1% in repeated injections, equivalent to the error reported by the microsyringe manufacturer), and system reliability was comparable to that of commercial models. Also, users do not need extensive knowledge in electronics or advanced computing to make osmar work as an autosampler, because it can easily be integrated with analytical instruments using AutoIt, a scripting language for the Windows Operating System. Therefore, osmar is a viable, low-cost, and technically-accessible alternative for automated sampling with microsyringes, and can be also adapted and expanded for more general liquid handling tasks.

Specifications table

Hardware name	Osmar
Subject area	• Chemistry and Biochemistry • Medical (e.g. Pharmaceutical Science) • Neuroscience • Biological Sciences (e.g. Microbiology and Biochemistry) • Environmental, Planetary and Agricultural Sciences
Hardware type	• Biological sample handling and preparation • Liquid and gas handling • Syringe manipulation
Open Source License	GNU General Public License (GPL) 3.0
Cost of Hardware	AU$700
Source File Repository	HardwareX

1. Hardware in context

Most scientific laboratories employ one form or another of automation in order to enhance productivity and safety, and also to

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Fig. 1. Osmar, the open-source microsyringe autosampler mounted on top of a gas chromatographer.

reduce human error [1–3]. A common tool to achieve automation in laboratories is the autosampler. Autosamplers are robotic devices that work together with analyzers allowing measurements to be done without the presence of an operator. Autosamplers are commonly purchased as an integral part of the analytical setup, and are often responsible for a substantial portion of its total cost.

It has been demonstrated that it is possible to use AutoIt, a scripting language for the Windows operating system, to enable the use of robotic arms instead of commercial autosamplers for several chemical analyses, thus cutting between 90 and 99% of the cost [4]. However, robotic arms can be complex to program because their movements consist of arcs, rather than straight lines. Also, some sampling tasks demand perfect linear movements - for example, syringe manipulation - which is often employed for gas or liquid sampling for gas chromatography, for example [5–9].

Linear movements can be achieved in a straightforward way by G-code devices [10], including 3D printers, computer numerical control (CNC) routers, and laser engravers. The cost of G-code devices has drastically declined in the last 5 to 10 years, to a point that currently such devices are very accessible to virtually any laboratory [11–14]. Therefore, there have been numerous examples of the application of such devices for scientific purposes, including chemical synthesis [15–17], fabrication of customized, low-cost laboratory utensils [18–21], liquid handling [18,22], fabrication of biological tissues [23,24], among many others [12,25].

Here we present osmar (**O**pen-**S**ource **M**icrosyringe **A**utosample**R**), which was built by modifying commercially available, low-cost (~AU$300 each) G-code devices. This should be attractive to low-income laboratories which are sometimes subject to unfair pricing, as in many underdeveloped nations [26] and to wealthier laboratories as a way to automate tasks and free staff time for more productive tasks. Importantly, building osmar demands very little technical skill (it is not much more difficult than assembling a large LEGO or IKEA set, for example), therefore being easily within the reach of most scientists and laboratory technicians.

2. Hardware description

Osmar consists of a movable gantry on which a vertical linear axis, also movable horizontally, holds a syringe driver (Fig. 1). This configuration is similar to that in commercial models performing sampling using microsyringes [27]. Such design allows the syringe to sample small and large vials, and also reach injection ports in instruments like gas chromatographers.

Because it is open-source, osmar can be built in many different sizes. Here, once fully assembled, osmar had a useful sampling space measuring 60 cm on the Y axis, 45 cm on the X axis, and 22 cm on the Z axis (Fig. 1). This is a large space comparable to that achieved by commercial models (e. g., the CTC pal autosampler in our laboratory has a sampling space measuring 70 × 23 × 21 cm).

Osmar has four moveable axes: X, Y (both horizontal; timing belt mechanism; the Y axis is duplicated), Z and E (both vertical; leadscrew and nut mechanism). Syringe movement is done by the X, Y and Z axes, while syringe plunger movement is done by the E axis. All movements are performed using stepper motors, which ensure movement reproducibility of < 1 mm. This movement pattern is similar to that found in different commercial models (e. g. CTC Pal).

Movement control using a computer is achieved with a MKS Gen-L control board, commonly used to control 3D printers. This board can control up to five stepper motors, which is the number of stepper motors used in osmar (4 axis plus the duplicated Y axis). Instructions can be sent using G-code, the standard widely employed in machines controlled by computers and that move in straight lines, like 3D printers, CNC routers and laser cutters [10]. Therefore, osmar is controlled using open-source and freely available