Supplementary Information

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1 Introduction

In this supplementary, we provide some extra detail on the hardware that we developed during the course of the project. As mentioned in the paper, methods for micro-plastic data collection are both costly and time consuming. Therefore proving that more cost effective methods can be readily available further motivates the project.

2 Further Motivation

The standard method for microplastic quantification is to use light microscopy. According to Hidalgo-Ruz et al. (2012), which reviewed 68 studies regarding microplastic identification and quantification, "In all reviewed studies, visual examination of the concentrated sample remains is an obligatory step. Careful visual sorting of residues is necessary to separate the plastics from other materials." Moreover, Primpke et al. (2020) states that "In many cases, light microscopy can be used without complex extraction methods, and researchers can be quickly and easily trained to visually identify MP.

However, the number of MP in a sample is commonly biased due to the difficulty in identifying non-obvious plastic particles from similar looking organic particles. More modern methods of MP classification have started adopting the use of machine learning for higher accuracy rates and efficiency. For example, Lorrenzo-Navarro et al. (2021) presents a "Deep learning approach for automatic counting and classification" that yields an impressive result: "A Jaccard index value of 0.8 is achieved in the experiments of particles segmentation and an accuracy of 98.11%". However, this method is unable to accurately quantify the amount of MPs in a sample as it relies on simply counting the number of MPs. Thus, important volume and mass information is lost in the process. As Hidalgo-Ruz et al. states, "The variable units in which abundance and mass of microplastics are reported become problematic when different studies are compared, even though units can be transformed in some cases".

We further motivate the 3D reconstruction of microplastics: Ward et al. find that "accurately modelling the shape of ... microplastic transport is crucial to determining the range and amount of deposition globally". The shape of microplastics are also significant in biological processes: according to Han et al. [**?**], "Nonspherical particles ... cylindrical polymer brushes ... and wirelike objects ... each [have] a unique influence on the cell".

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3 Hardware

After purchasing some digital microscopes online for testing purposes, amounting to around 20 GPB per unit, we quickly realised that focusing and adjusting the position of the microscopes for every sample of micro-plastics we wanted to analyse was tedious and inaccurate. Thus we sought a way to automate this process cheaply. After disassembling the original microscope, we found that the focus system was manual, using a simple translation screw to convert the rotary motion of the wheel to the vertical linear motion of the focusing lens. In light of this, we designed our own translation screw with gear teeth around its circumference, such that a stepper motor with a corresponding gear attached could be used to actuate the movement of the lens through a computer, thus leading to increased precision.

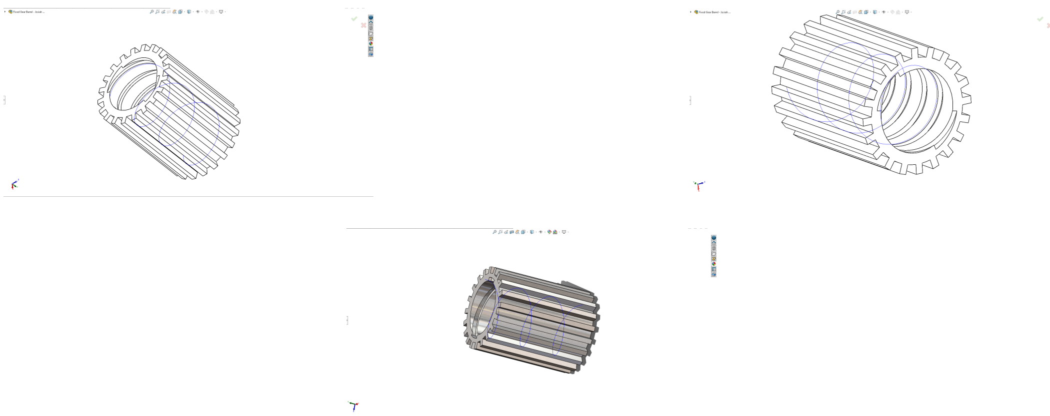

Figure 1: CAD model for the Translation Screw

The part was modelled in SolidWorks, which we then used a filament printer for rapid prototyping of each subsequent iteration of the part until completion. The final piece was printed on a resin printer so that the thread on the inside was as smooth and accurate as possible.

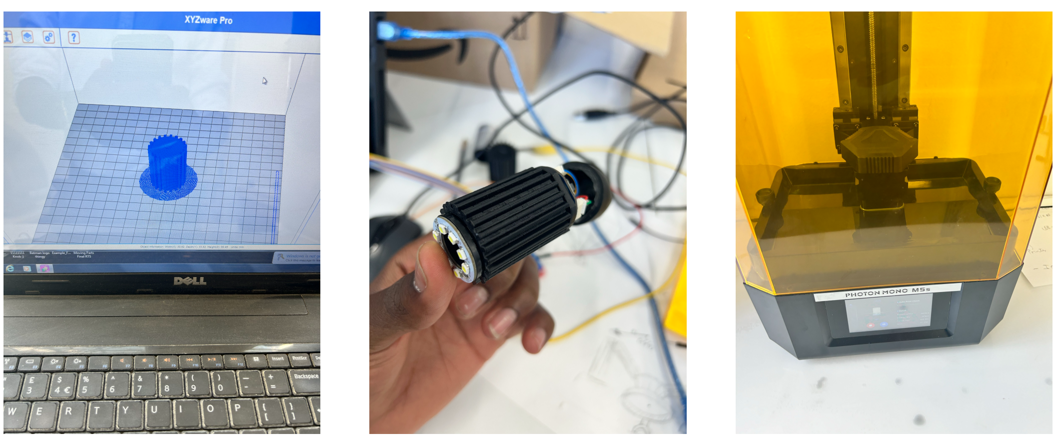

Figure 2: Different Methods for Prototyping

After testing the part to make sure it could move the lens as effectively as the original microscope piece could, we then moved on to the electronics. We opted to use a 12V stepper motor powered by an Arduino Uno, using an external 12 volt power supply and a motor driver.

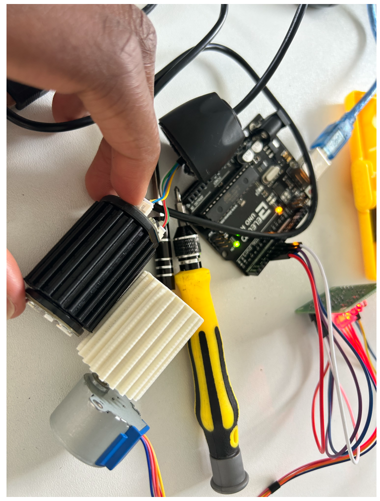

Figure 3: Microscope Autofocus Mechanism

After 3D printing an additional part with the same gear ratio as the first and attaching it to the motor, we could now easily actuate the movement of the lens, and therefore automatically adjust the resulting focus of the microscope. The gear piece was designed such that the full range of motion from minimum to maximum displacement of the lens can be achieved through a 270 degree rotation of the translation screw.

Thus we are able to effectively calculate the position of the microscope lens in 3D space. For each sample of microplastics, starting from the minimum displacement position and taking a photograph for each small displacement of the lens and storing the data in a hash map, we can effectively collect data sample quickly and cheaply.

3.1 More Figures

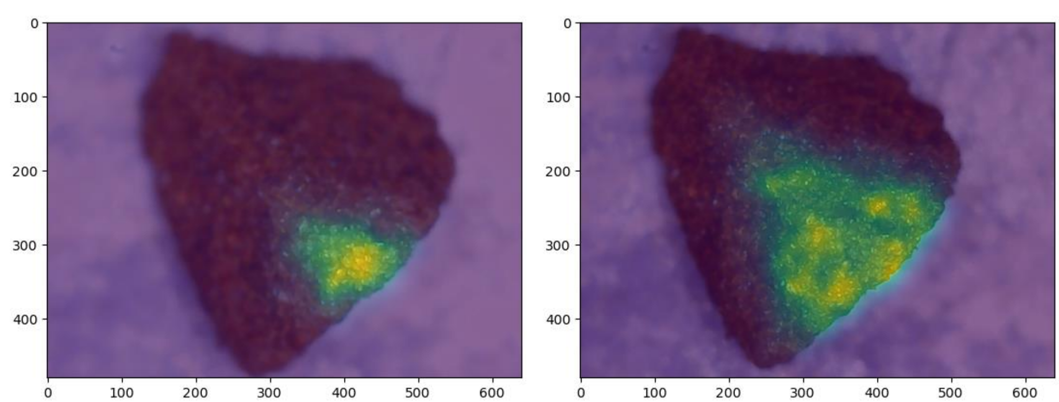

Figure 4: Focus Map for a microplastic at different magnifications

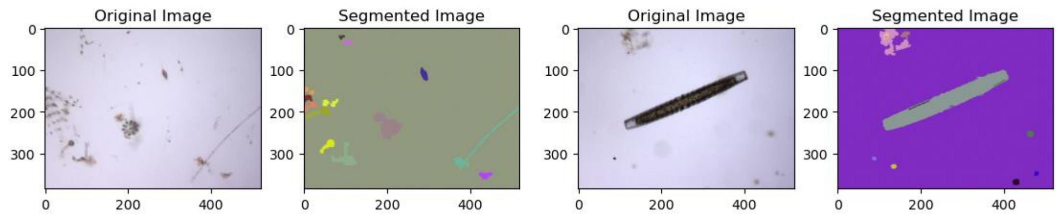

Figure 5: Negative Sample segments

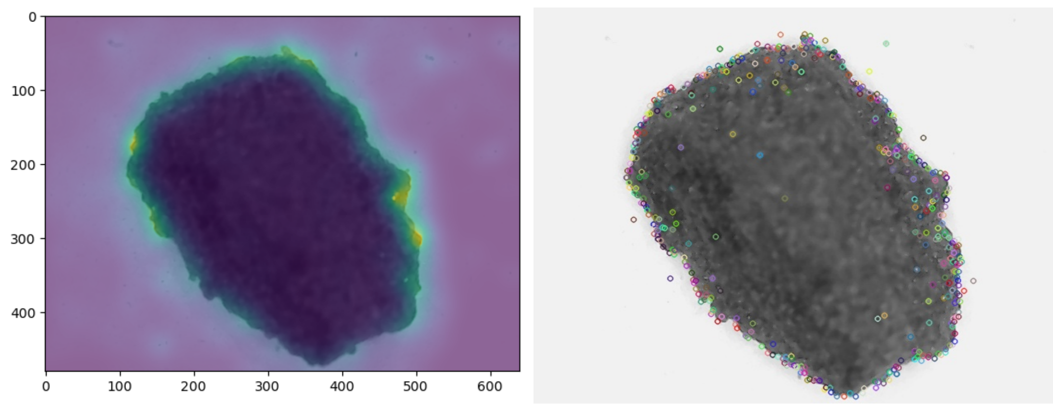

Figure 6: Left: Image of microplastic with overlayed focus mapRight: Example of generated key-points from SIFT algorithm.