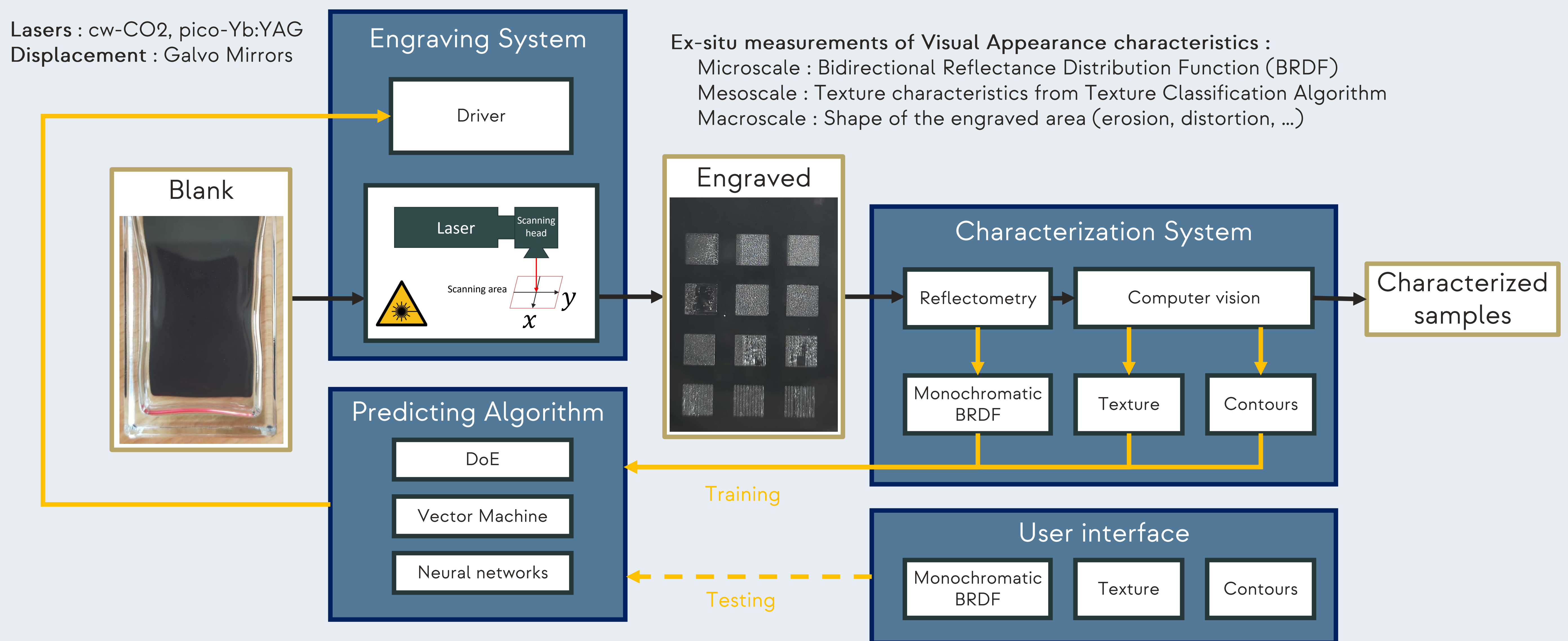


# Smart Laser Engraving System for Industrial Glass Texturing

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## Abstract

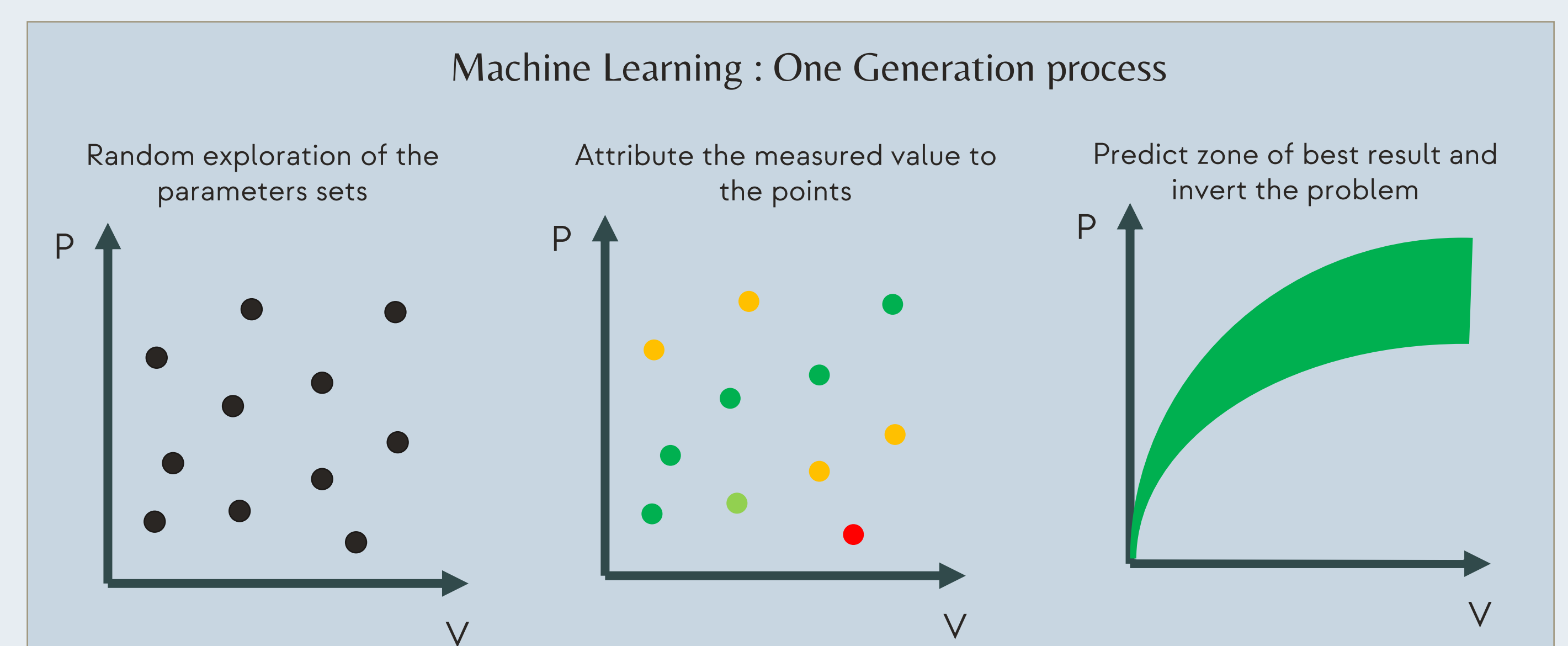
Laser beams are advantageous tools for materials texturing. The absorption of the energy delivered by the laser is a key parameters for the interaction. The use of middle-range infrared wavelength ( $10.6 \mu\text{m}$ ) allow great absorption by all kind of silicate glass. Moreover, ultra-short pulse (ultra-high intensity) laser also allow good absorption by non-linear effect on a large range of materials. Despite a good knowledge of the light-matter interaction in the literature, decorative industrial processes of glass involve numerous aspects that significantly increase the difficulty for material texturing, i.e. unknown material properties from glass manufacturers, lack of quantitative indicators for material texturing characteristics and experience-based process parameters optimization. This collaboration project aims to create a system that solves those problematics by, first, studying the laser-matter interaction processes that are viable for industrial decoration of silicate glass. Second, setup a characterization system that extracts all the information from the glass surface required for decorative purposes. Third, translate visual information into laser beam process parameters.



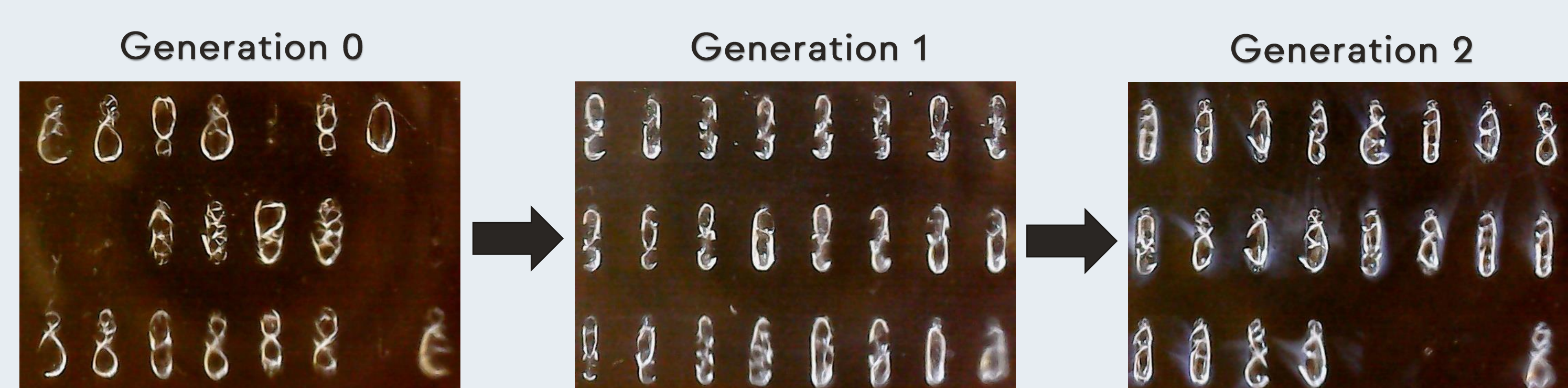
## Aesthetic engraving



## Machine learning prototype



Engraving instruction : Matrix of 24 vertical lines of 2 mm  
Characterization tool : USB Camera  
Optimization criterion : Maximize vertical length



## References

- [1] Ultra high-speed micromachining of transparent materials using high PRF ultrafast lasers and new resonant scanning systems (Conference Paper), Harth, F., Piontek, M.C., Herrmann, T., L'Huillier, J.A., *Proceedings of SPIE* (2016).
- [2] High-aspect-ratio crack-free microstructures fabrication on sapphire by femtosecond laser ablation, Liu, H., Li, Y., Lin W., Hong M., *Optics and Laser Technology*, 2020.

## Academic dimension

Study the light-matter interaction of different laser on industrial glass. Simulate with Finite Element Methods (FEM) thermal cycles effects on glass physical properties and surface characteristics, especially transient thermal stress and stress relaxation phenomena when above  $T_g$ . Quantitatively define engraving appearance of glass for decoration purpose. This methods will be extended to other transparent media. Use predicting algorithms based on machine learning to translate engraving appearance to laser engraving process parameters.

## Industrial dimension

This projects aims to narrow the frontier between Art and Science. This system will ease the use of lasers for decoration purposes by giving the possibility for designers to have 3D models of the glass surface texture and directly work with appearance parameters.

The development of a systematic method for transparent material texturing will allow to reduce the time required to find the desired process parameters and save high value-added material.