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POLISHING SIMULATION

SPR (Simulation of Polishing Result) is a two-dimensional geometric simulator designed to reproduce the macroscopic effect of a stone polishing tool. The SPR divides the stone and instrument surfaces into tiny two-dimensional sections, the so-called pixels, and assumes that the accumulated contact between the pixels of both surfaces, that is, surface grinding, can be used to determine the main aspects of the polishing process.

Different polishing tools can be simulated by simply determining the amount of erosion for each instrument pixel, from 0 (no contact) to any positive number. For example, the surface of the tool can be designed to have a predetermined distribution of diamond and connecting pixels.

Figure 1 shows three different polishing tools, each of which consists of six Frankfurt abrasives, which are commonly used for polishing marbles: 320TX, 400T and 5Extra.

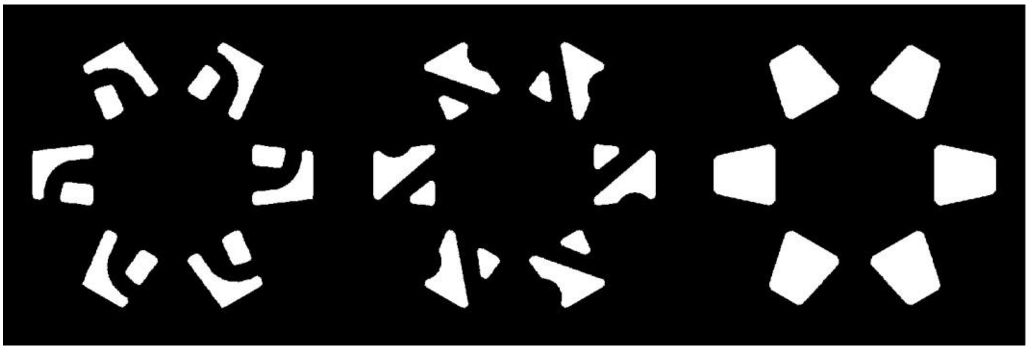

Fig. 1. Simulation of polishing abrasives: 320TX (left), 400T (center) and 5Extra (right).

Different sections of the simulation, with different tools, different speeds and movement of the instrument can be created, even with different time steps. Figure 2 shows the results of polishing obtained using the same tools as in FIG. 1, after one rotation at 10 rev / s (without moving) in increments of 0.001 s, corresponding to an angle of 3.6 degrees between each reflection.

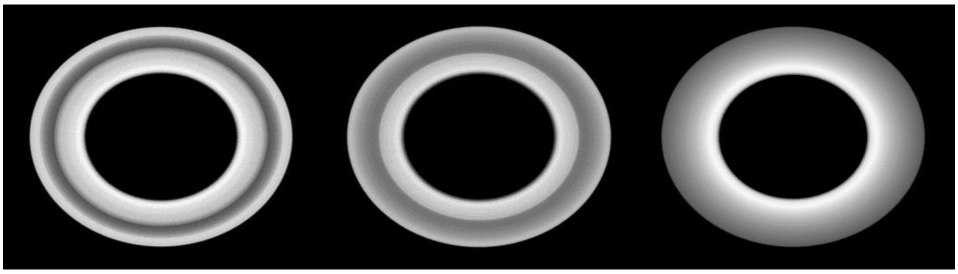

Fig. 2. Simulated polishing by the same tools as in Fig. 1, with abrasives: 320TX (left), 400T (center) and 5Extra (right), after one rotation at 10 rps, with a time step of 0.001 s.

SPR provides a very simple (only five instructions) But powerful advice to determine the path through which a stone tool should move, including multi-level loops and random sequences of linear segments and arcs of a circle, which operate in a wide range of parameters. This feature allows users to explore virtually unlimited number of trajectories. Figure 3 shows the polishing results obtained with a simple tool disk for two different polishing paths: mostly linear trajectory polishing and a more complex, mostly circular trajectory.

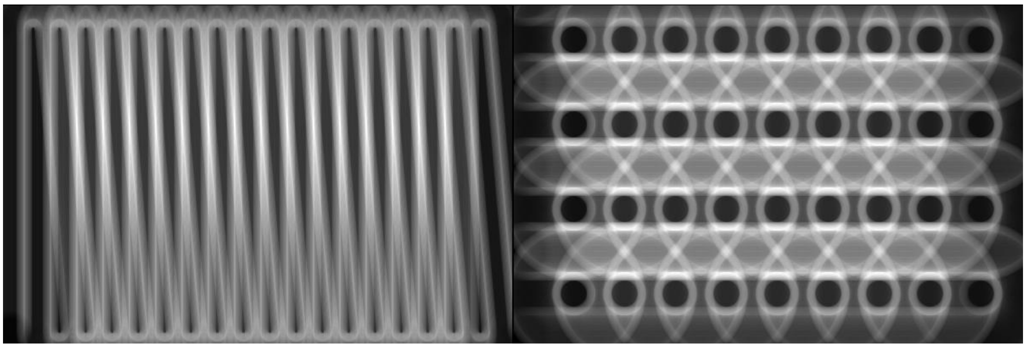

Fig. 3. Simulated polishing by a simple circular disk, for two different tool trajectories. Left: a mostly linear, up-and-down trajectory, circular on the borders. Right: a complex, four-row trajectory, mostly formed by circular movements, simulating multi-level circular hand polishing.

The accumulated simulation results for each pixel of a stone are stored in files describing five properties, which are one of the determining factors in the polishing process: 1) general abrasion; 2-3) shifts in pixels (in horizontal and vertical directions) between each polished pixel and the central pixel of the instrument; 4-5) average distance and standard deviation between the polished pixel and the center pixel of the instrument.

The main goal we want to achieve with PAM is to create a simulation laboratory that will help us to optimize: 1) polishing tracks, automatically generated by a controlled algorithm for cutting machines (based on robot and CNC) in industrial conditions; 2) the shape and texture of new polishing tools, which can be modelled primarily to eliminate bad designs, before real prototypes of tools are made and experimental experiments begin.

To obtain a properly polished surface of the stone, it is not enough to achieve high levels of abrasion across the entire surface of the stone: the erosion should be as homogeneous as possible and applied accidentally, to avoid scratches and other visual defects on the surface. For economic reasons, the polishing trajectory should be as short and quick as possible, and the surface of the stone should not be excessively polished.

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