Modeling and Control of Inkjet Printhead[1]

Mohammed Ezzeldin, Andrej Jokic and Paul van den Bosch
Department of Electrical Engineering
Technische Universiteit Eindhoven
P.O. Box 513, 5600 MB Eindhoven
The Netherlands
Email: m.ezz,a.jokic and p.p.j.v.d.bosch@tue.nl

1 Introduction

Inkjet printers are non-impact printers which print text and images by spraying tiny droplets of liquid ink onto paper. Besides the well known small inkjet printers for home and office, there is a market for professional inkjet printers. Inkjet printers are used to form conductive traces for circuits, and color filters in LCD and plasma displays. That makes the printing quality is an important issue. Currently, most inkjet printers use either thermal inkjet or piezoelectric inkjet technology. Thermal inkjet printer uses heating element to heat liquid ink to form vapor bubble, which forces the ink droplets onto the paper through the nozzle. Most commercial and industrial ink jet printers use a piezoelectric material in an ink-filled chamber behind each nozzle instead of a heating element. When a voltage is applied, the piezoelectric material changes shape or size, which generates a pressure pulse in the fluid forcing a droplet of ink from the nozzle. This is essentially the same mechanism as the thermal inkjet but generates the pressure pulse using a different physical principle. Piezoelectric ink jet allows a wider variety of inks than thermal or continuous ink jet but the print heads are more expensive. In my project the piezoelectric inkjet printer is considered.

2 Problem Statement

After a drop is jetted, the fluid-mechanics within an ink channel are not at rest immediately: apparently traveling pressure waves are still present. These are referred to as residual vibrations. These residual vibrations result in changing the speed of the second drop. Usually the fixed actuation pulse is designed under the assumption that a channel is at rest. To guarantee consistent drop properties, one has to wait for these residual vibrations to be sufficiently damped out to fulfill this assumption.

Cross-talk is the phenomenon that one ink channel cannot be actuated without affecting the fluid-mechanics of the neighboring channels. The cross-talk happens due to the fact that the pressure waves within one channel influence other channels. This type of cross talk is called acoustic cross-talk. Since all piezo-fingers are connected to a substrate, a deformation of one piezo-unit induces a deformation of the neighboring units. Another path is via the deformation of a channel itself. As a result, the volume of the neighboring channels changes also which induces pressure waves in those channels. Residual vibrations and cross-talk result in ink drops with different speed and volume which affect the printing quality. The main goal is to improve the printing quality of the printhead that is achieved by keeping both the speed and volume of the ink drop constant. In other word, to minimize the speed and volume variations occur because of the residual vibration and cross-talk.

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3 Identification and Control Approach

Since there are no online measurements for the system variables, a feedforward controller is the most appropriate solution. Although residual vibration and cross-talk effects are large, they are very predictable and reproducible. Hence, a model based feedforward controller can be appropriate for this case. Different approaches for modeling and control are given in [1] and [2]

The main idea of the proposed approach is to identify the dynamics of every channel and also the coupling dynamics with the neighboring channel. In the test setup, both the channel pressure and the meniscus speed can be measured. Hence, the system can be decomposed into two subsystems, the first one represents the dynamics between the input voltage and the channel pressure and the neighboring channel pressure. The second subsystem represents dynamics between the pressure and the meniscus speed. If the identified model represents the system exactly, the controller could be some kind the inverse of the identified model. Hence, the actual drop speed and volume will be almost the same as the desired input speed and volume.

References

[1] H.M.A. Wijshoff, "Structure- and fluid-dynamics in piezo inkjet printheads,"PhD thesis, 2008.

[2] M. B. Groot Wassink,"Inkjet printhead performance enhancement by feedforward input design based on two-port modeling," PhD thesis, 2007.