Modeling Clogging in Microfluidic Devices

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Background

- Clogs form when particles in a fluid block flow through a channel. Clogging is a common but poorly understood
- Microfluidic devices are an ideal medium for observing clogs. Examples include:
  - water filtration systems
  - inkjet printers
  - blood vessels and biomedical devices
- Clear understanding of clogging can be used to prevent clogs, improving device performance and lifetime
- **Goal**: develop computational model to characterize how clogs form

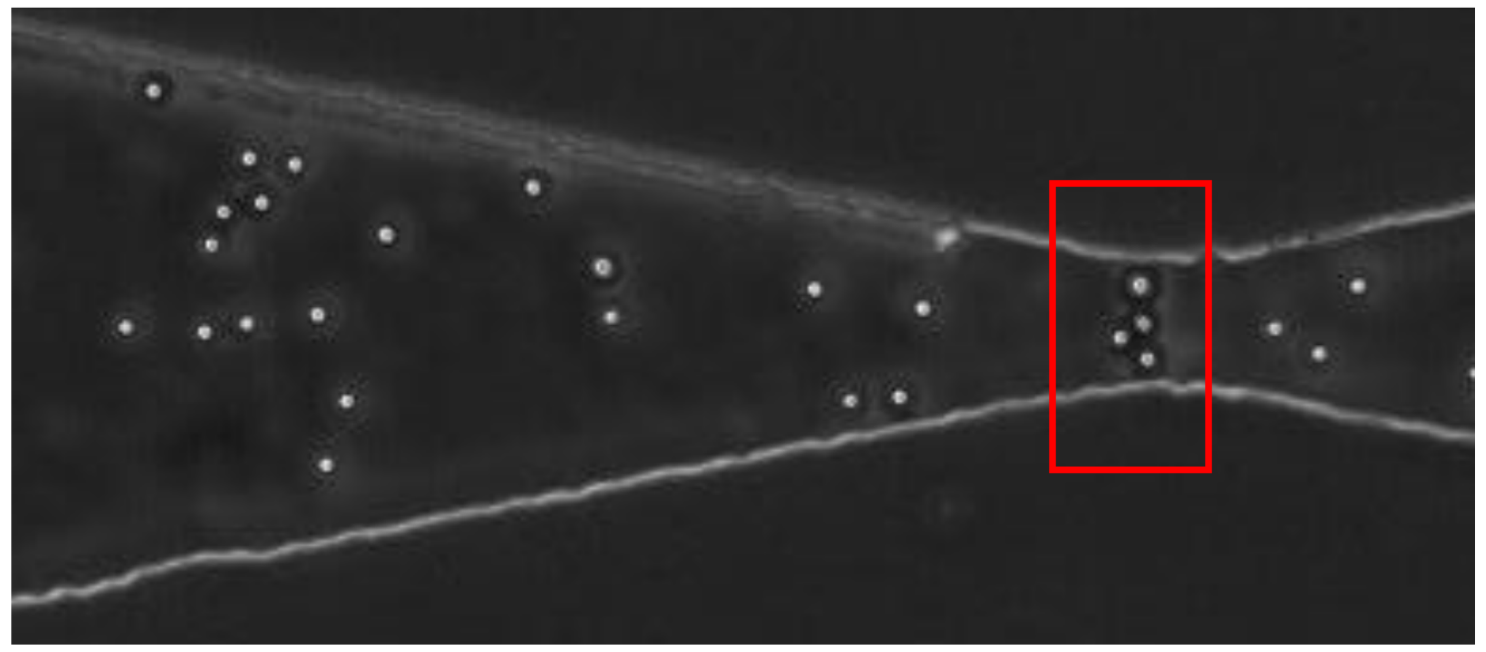
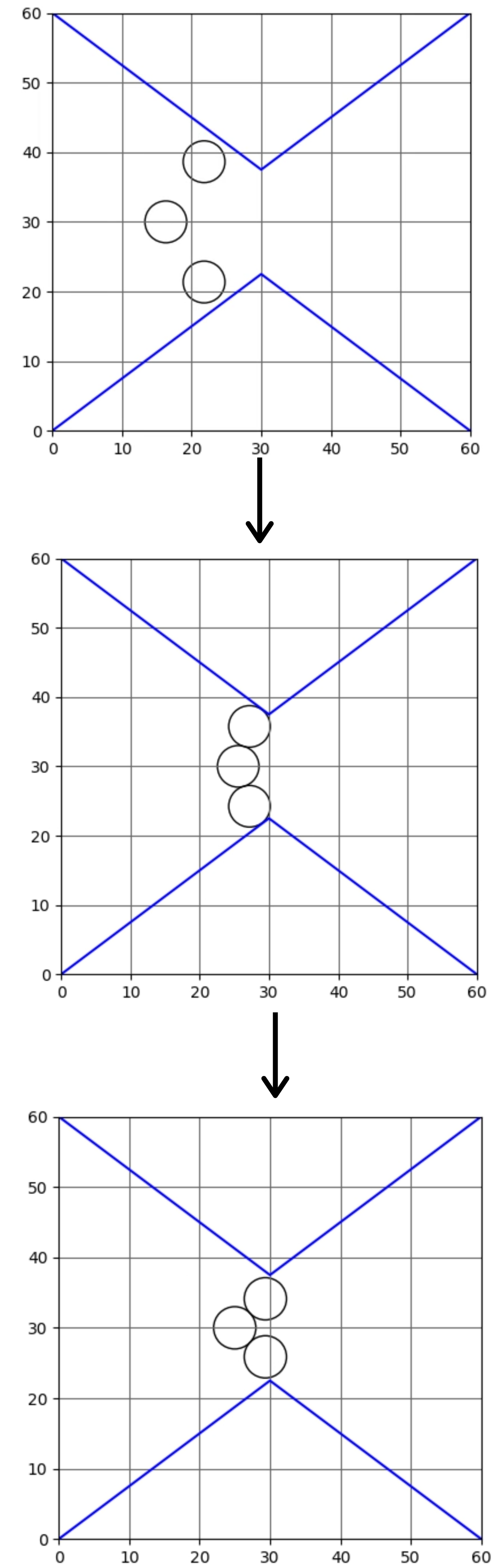


Figure 1: Photograph of a clog in a microfluidic device, marked in red. Particles form an arch over the channel constriction. Courtesy of Prof. Jeff Guasto, Sydney Holway

Methods

- Modeled the velocity profile of fluid flowing through a channel with a given geometry
- Calculated forces acting on particles in the fluid based on interactions with fluid, other particles, walls
- Simulated particle motion through the channel
- Identified clogging events
- Analyzed stability of different clog configurations

Results



t = 0
Particles start out flowing through the channel, transported by carrier fluid

A clog forms when particles create an arch over the channel constriction

The clog is not fully stable, it will eventually start to collapse

Figure 2: the progression of a clogging event. Images show position of particles in a channel at different timesteps. Channel walls are marked in blue. Fluid flows left to right.

Conclusions

- It is possible to create a geometric clog that is held in place by its arch geometry rather than adhesive forces
- Clogs can form spontaneously
  - Not dependent on particle accumulation on the walls
  - Clogs form when particles are in the right position at the right time to form an arch
- Clogs are *metastable*: they do not last indefinitely
  - Metastable clogs could be stabilized with the accumulation of more particles to reinforce the arch

Future Steps

- Add friciton to further stabilize clogs
- Explore effect of adhesive forces between particles and walls
- Use a more complex fluid dynamics model that accounts for particle positions disrupting flow

Acknowledgements

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