Pneumatic Digital Computer

Tech ID: 24604 / UC Case 2015-145-0

BRIEF DESCRIPTION

Researchers at the University of California, Irvine have developed a computer that is built out of pneumatic valves instead of electronic transistors. The system is built using microfluidics technology and can be employed for integrated control of lab-on-a-chip devices.

FULL DESCRIPTION

Computers typically represent binary information as differences in voltage across an electrical network on a semiconductor chip. Our computer represents binary information as differences in pneumatic pressure across a network of channels and valves on a microfluidic chip. We employ a finite state machine architecture: bistable pneumatic elements serve as the state register, and pneumatic Boolean circuits serve as the next-state logic. The next-state logic can be reconfigured by changing the placement of holes punched in a membrane, thus the computer is programmable.

Such a computer is well suited for controlling pneumatically driven systems. In particular, we have demonstrated the control of liquid valves and pumps for programmed liquid handling. A single microfluidic chip can integrate liquid handling circuits as well as the control logic required to drive these circuits, such that off-chip computers and machinery are not required to operate the device. Electrical power is also not needed. Instead, only a weak vacuum is required, such as that which can be provided by manually pulling on a syringe.

SUGGESTED USES

This technology may be employed to create self-contained lab-on-a-chip devices that are lower cost and more compact than current approaches to integrated microfluidics. Control of other pneumatically driven systems such as soft robotics may also be possible. Other applications could include computers and actuators that operate in high-field settings such as magnetic resonance imaging, or high-radiation settings such as nuclear reactors or outer space. There may also be applications in security, involving computers that have no electromagnetic signature.

ADVANTAGES

The control of pneumatically driven systems typically requires an electronic controller, a set of electro-mechanical valves to regulate pneumatic pressure, and a network of tubing for routing pneumatic forces to the required locations. In microfluidic lab-on-a-chip systems, this control machinery is typically much larger and more costly than the microfluidic chip itself. For many applications, such as point-of-care diagnostics, it may be advantageous to be rid of this off-chip control machinery. This is possible by using microfluidic circuits to build both liquid handling networks as well as the control logic that is required to drive these networks, through the use of our pneumatic computing technology.

PATENT STATUS

Country	Type	Number	Dated	Case

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OTHER INFORMATION

KEYWORDS

Microfluidics, Pneumatic, Digital logic

CATEGORIZED AS

- **Biotechnology**
  - Other
- **Computer**
  - Hardware
- **Medical**
  - Devices
  - Diagnostics
- **Engineering**
  - Other
  - Robotics and Automation

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RELATED CASES

2015-145-0

LIMITATIONS

The chips are not completely autonomous, as a power source is still required. Specifically, a weak vacuum is required. This can be provided by a vacuum line as commonly found in labs and clinics, or by manual pumping.

STATE OF DEVELOPMENT

We have demonstrated operation of a programmable 2-bit finite state machine. The number of memory bits can be increased to roughly 10 bits with currently available technology, enabling programs with ~1000 individual steps.

TESTING

We are currently working to demonstrate automated medical diagnostic assays with this technology.

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