Undergraduate Thesis Prospectus

Automation of Air Removal in an Intravenous (IV) Line

(technical research project in Computer Engineering)

For a Free and Open Web: The Fight for Net Neutrality

(sociotechnical research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.
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STS advisor: Peter Norton, Department of Engineering and Society

General research problem

How can system efficiencies be improved?

System efficiency gains are generally desirable but may introduce unanticipated and undesirable effects. Automation, for example, may improve system efficiencies, but may also disrupt employment, preclude valuable expert human judgment and experience, or serve as a pretext to increase per-person workloads (Jacobson & Roucek, 1959; Brugger & Gehrke (2018). Similarly, in service provision, regulatory access controls intended to improve efficiency may diminish equity, but deregulation may shift balances of power in inequitable ways (Kahn, 1970; Kahn, 200). In healthcare, media, and other sectors, study of such effects may disclose means of better managing them.

Automation of Air Removal in an IV Line

How can the removal of air from an IV line be automated?

For my Computer Engineering capstone project, I am collaborating with Manuel Alvarado, Leah Bianchi, Orian Churney, and Quinn Lewis to automate removal of air bubbles from intravenous (IV) lines used by infusion pumps. Our technical advisor is Professor Harry Powell.

IV fluids are often administered in hospitals via an infusion pump, which controls the drip speed and detects anomalies in the system. Air can enter an IV line during the manufacturing and filling process for the plastic IV fluid containers or when drugs/fluids are first added to the line (Munson, 1993). Bubbles can put the patient at risk for fatal venous air embolism, especially older patients and those with comorbidities (Miller, 2016).

The infusion pump alerts the patient and healthcare workers when air is present in the line. Removal of air is often done with a “flick and float” technique (fig. 1) (Miller, 2016)

(Bianchi, 2020). Our project is to create a device that automates this process by using previously existing technology to detect air in line while a mechanical action is carried out in an attempt to remove the bubble.

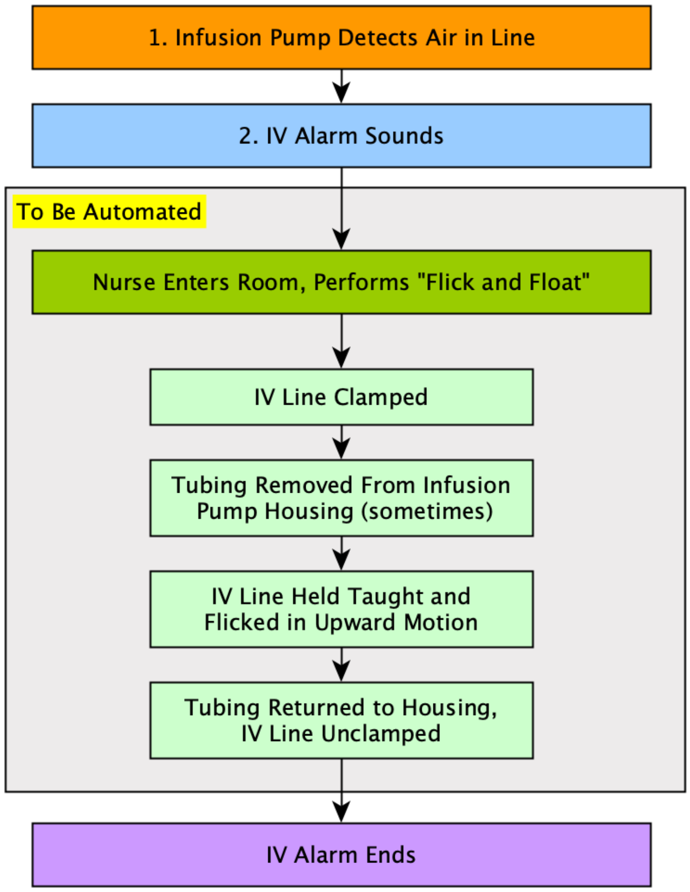

Figure 1. State-of-the-art procedure to remove air from line

The mechanical action will consist of vibrational motors placed along the line. An MSP-432 microcontroller will control the vibration strength and duration for each motor using pulse-width modulated (PWM) signals. Prior art shows that controlling vibration via PWM signals is not a new concept (Elliott, 2015) (Roy et al., 2017). Nor is using vibration to separate liquids and gases (Prisco et al., 2011) (Nicholls & Warren Jr., 1997) (Horikawa, 1980). However, this project involves additional challenges, notably the need to integrate with pre-existing pump systems present in hospitals.

While many techniques can remove air from a line, our device will only automate the first, simplest method carried out – the "flick and float" technique. To do this, the device will need to carry out three main functions: 1) detect when air is in line, 2) delay the IV alarm and, 3) carry out a mechanical action equivalent to what a nurse would do when first attempting to remove air bubbles. To accomplish this, the device will contain three subsystems: 1) an alarm detector to activate our device when the pump detects air in line, implemented as a microphone with a bandpass filter of center frequency equivalent to the alarm frequency. 2) A controller to manipulate parameters for the mechanical action, implemented on an MSP-432 microcontroller. 3) The mechanical (vibrational) subsystem to influence the line as directed by the controller. The state of the program can be represented as a finite state machine (fig. 2) (Bianchi, 2020):

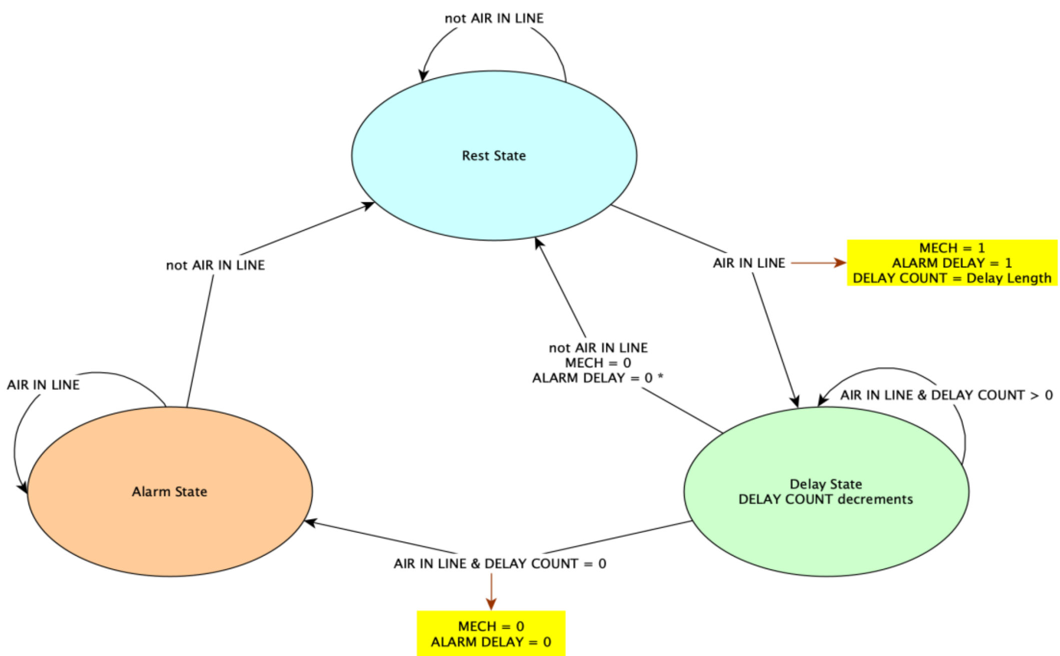

Figure 2. Finite state diagram of device functionality

The device will utilize several subsystems on the MSP-432, linked together by our printed circuit board (PCB). It will use the analog-to-digital converter (ADC) and filter to detect the microphone, MicroController Unit (MCU) to perform calculations and keep the state of the machine, and digital-to-analog converter (DAC) to send voltages to the motor. Figure 3 depicts the interaction between these subsystems (Bianchi, 2020):

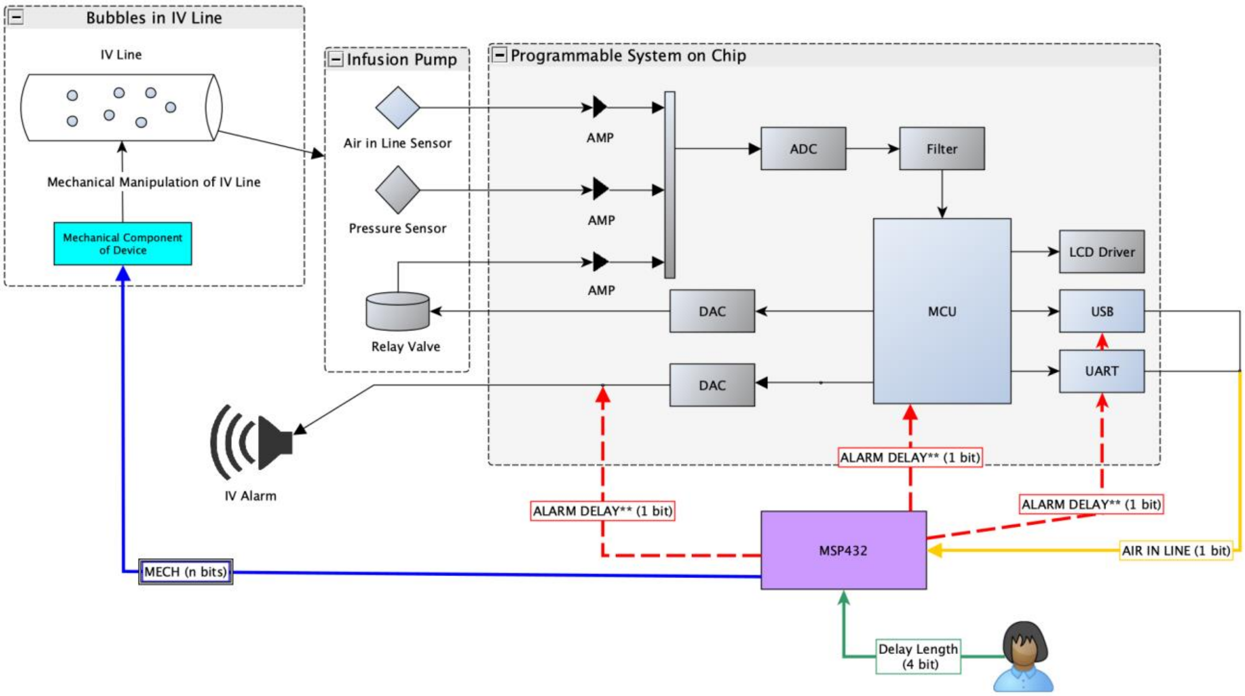

Figure 3. Block diagram of interactions between subsystems and infusion pump components

We will evaluate the device on several criteria, including flexibility in handling different fluids/conditions and effectiveness in clearing air-in-line hazards. When finished, our device should be able to handle a wide range of viscosities and densities. While we do not anticipate being able to receive governmental/regulatory approval by the end of the semester/year, our project will serve as a proof-of-concept that could eventually be developed into a full-scale product incorporated into new systems.

For a Free and Open Web: The Fight for Net Neutrality

Since 2010, how have social groups competed to influence U.S. net neutrality regulations?

Network neutrality in principle has been applied to radio and telephony networks since the 1930s. Since the 1990s, many have proposed extending such common carrier regulations to the Internet (Troiano, 2019). In 2017 the Federal Communications Commission substantially repealed federal net neutrality rules, but state-level efforts continue. By 2019, bills or resolutions had been introduced in 37 states, but only four had passed a net neutrality law (Landgraf, 2019).

Sohn (2019) has reviewed the case for net neutrality: Unlike radio and television, which are top-down, centrally controlled, and ruled by a profit motive, the Internet is a bottom-up, democratic, decentralized network where users control the content. Thus, social movements that other media often ignore or misrepresent thrive online. She suggests that marginalized voices may not be heard "if the companies that provide access to the Internet can pick and choose, for pay or not, what content, applications, and services get to the user faster or with better quality of service." Repealing net neutrality "takes away Internet Freedom from those who need it most — the public" (Sohn, 2019).

Kaplan (2018) summarizes anti-net neutrality arguments. He suggests that many vertical agreements (for example, about prioritized content) benefit consumers and that under Title II, "a substantial number of false positives, beneficial vertical agreements, are prohibited." He notes that Title II bans prioritization of vitally important content, such as telemedicine (Kaplan, 2018).

Bauer and Obar (2014) note that “viewpoint bias” sometimes constrains the debate: “stakeholders primarily interested in political goals assert that their proposed solutions also promote economic objectives,” and vice versa. They contend that because “no single policy instrument can achieve widely shared economic and political goals simultaneously,” competing interests must settle for an imperfect balance or a rough consensus. Bauer and Obar classify six net neutrality arrangements: strict neutrality, prohibition of blocking, zero price constraint, minimum quality of service tiering, quality of service tiering with nondiscrimination safeguards, and unrestricted quality of service tiering (2014).

Most Internet users favor net neutrality. About 86 percent of Americans oppose the net neutrality repeal (PPC, 2018). Brewer et al. (2017) suggest news viewership preferences shape consumers’ opinions on net neutrality.

Consumer and civil rights advocacies are engaged in the debate. Consumer advocacies object to higher costs. According to Jonathan Schwantes of Consumers Union: following repeal of net neutrality, “Internet providers are now free to move forward on the anti-competitive practices they were flirting with”; practices “that place smaller businesses at a disadvantage and ultimately cost consumers more” (Willcox, 2018). Civil rights groups demand regulations to secure equity of Internet access. In a statement endorsed by the NAACP, the Multicultural Media, Telecom & Internet Council declared: “We support a permanent statutory solution that enshrines the basic open internet principles into law. These core principles are not controversial and should not be subject to endless litigation, regulation, and reconsideration" (MMTC, 2017).

Semi-organized and organized anti-net neutrality groups include Internet service providers (ISPs), ISP trade unions such as the Internet & Television Association (NCTA), and market-oriented think tanks. Remensperger (2017) finds that trade associations' arguments are practical: Net neutrality increases market complexity and costs, and impedes ISPs' efforts to expand and upgrade service. Think tanks, however, are more ideological, referencing property rights and economic principles.

ISPs deploy rhetoric evocative of net neutrality while actively opposing it. Comcast appeals to customers by claiming to be "committed to an Open Internet": they "do not block, slow down, or discriminate against lawful content" (Comcast, n.d.). However, Open Secrets reveals Concast as the third-highest-spending anti-net neutrality lobby, behind AT&T and Verizon (Leathley, 2017).

Trade associations and think tanks are often funded by or closely associated with ISPs and have a target audience that opposes net neutrality; thus they rarely feign support for regulation. NCTA suggests that because of the repeal, "ISPs are investing in better and faster networks" and that "the Internet will remain neutral and open" (NCTA, 2018). Similarly, the Cato Institute, a libertarian think-tank, asserts that the Internet needs no regulation: "during the development of the Internet from its early days to the present, regulation, including net neutrality regulation, has actually had very little effect" (Doren & Firey, 2017).

Content providers (CPs), such as Netflix, vary with respect to their economic agenda. According to Guo et al. (2017), "under certain conditions, it is economically beneficial for the dominant CP to reverse its stance on net neutrality” (Guo et al., 2017). Smaller companies benefit more from net neutrality because they generally cannot outbid large corporations for favored content. In 2017, Netflix’s CEO, Reed Hastings, argued: “where net neutrality is really important is the Netflix of 10 years ago. And it’s important for society, innovation, and entrepreneurship ... but it’s not our primary battle at this point” (Recode, 2017). This is only generally true, however. Large content providers and social media corporations may support net neutrality if serves their branding and flatters their consumer base; Reddit is a case in point (u/spez & u/kn0thing, 2017).

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