Abstract Writing Instructions

Why: In Drew's experience, abstracts have a common form, which is easy to follow if you know how. Reading these examples will help you write your abstract! -Drew, 2023-08-17

Abstract Content:

1. Big problem statement about how your subject of study, if successful, could do important things. (1 sentence).
2. However, there's a crucial part of the story that isn't possible just yet, which limits [some specific capability]. (1 sentence).
3. This article develops a method for [addressing limitation / creating capability] by [our insight which made the article possible]. (1 sentence.)
4. Something about the technical specifics of the problem, and how your particular solution addresses those technical specifics, with engineering reasons or motivation behind it. (1-2 sentences.)
5. Your approach, the experiments you did. (2-3 sentences max.)
6. Results showed that [limitation was overcome / capability was addressed, ideally with "X% improvement" or "shown in proof-of-concept for the first time"]. (1-2 sentences.)
7. These results enable [future directions that could address limitations in this work, if the results were not super convincing but we're trying to publish them anyway], or some statement that refers back to the first sentence. (1 sentence.)

Total:
8 sentences, +/- 1 sentence depending on your writing style.
150-190 words approximately.

What is not here:

- Background/literature review. (*why:* not crucial, takes up space, covered by sentence #2.)
- Vague claims that are not justified by the results or data. (*why:* opens you up to criticism / some people might disagree with you.)
- Meaningless words or phrases: "enormous potential to…" (*why:* some people might disagree with you!)
- Opinions. (*why:* not science.)

Examples, with annotations, at each page break below!

.
.
.

1. *Safe Supervisory Control of Soft Robot Actuators*
    a. theoretical result example.
    b. https://arxiv.org/abs/2208.01547

Abstract:

Although soft robots show safer interactions with their environment than traditional robots, soft mechanisms and actuators still have significant potential for damage or degradation particularly during unmodeled contact. This article introduces a feedback strategy for safe soft actuator operation during control of a soft robot. To do so, a supervisory controller monitors actuator state and dynamically saturates control inputs to avoid conditions that could lead to physical damage. We prove that, under certain conditions, the supervisory controller is stable and verifiably safe. We then demonstrate completely onboard operation of the supervisory controller using a soft thermally-actuated robot limb with embedded shape memory alloy (SMA) actuators and sensing. Tests performed with the supervisor verify its theoretical properties and show stabilization of the robot limb's pose in free space. Finally, experiments show that our approach prevents overheating during contact (including environmental constraints and human contact) or when infeasible motions are commanded. This supervisory controller, and its ability to be executed with completely onboard sensing, has the potential to make soft robot actuators reliable enough for practical use.

Breakdown:

Although soft robots show safer interactions with their environment than traditional robots, soft mechanisms and actuators still have significant potential for damage or degradation particularly during unmodeled contact.
^^ (1)-(2) big problem statement: soft robots show safer interactions. Crucial limitation: can still damage or degrade.

This article introduces a feedback strategy for safe soft actuator operation during control of a soft robot.
^^ (3) our contribution that addresses limitations.

To do so, a supervisory controller monitors actuator state and dynamically saturates control inputs to avoid conditions that could lead to physical damage.
^^ (4) technical insight that addresses technical specifics of the problem.

We prove that, under certain conditions, the supervisory controller is stable and verifiably safe.
^^ (5) part of our approach was a stability proof

We then demonstrate completely onboard operation of the supervisory controller using a soft thermally-actuated robot limb with embedded shape memory alloy (SMA) actuators and sensing.

^^ (5)-(6) part of our approach was implementation on SMAs specifically, on this particular hardware platform.

Tests performed with the supervisor verify its theoretical properties and show stabilization of the robot limb's pose in free space.
^^ (6) we confirmed the basics, not super related to the main claim, but necessary as part of the overall idea

Finally, experiments show that our approach prevents overheating during contact (including environmental constraints and human contact) or when infeasible motions are commanded.
^^ (6) we confirmed the main important things

This supervisory controller, and its ability to be executed with completely onboard sensing, has the potential to make soft robot actuators reliable enough for practical use.
^^ (7) wow isn't this great! You should try it out or cite it if you're trying to build a similar robot.

2. *Double-Helix Linear Actuators*
    a. design result example, includes both theoretical analysis and hardware.
    b. https://asmedigitalcollection.asme.org/mechanicaldesign/article/143/10/103301/1106100/Double-Helix-Linear-Actuators

Abstract:

Many robotic systems require linear actuation with high forces, large displacements, and compact profiles. This article presents a series of mechanisms, termed double-helix linear actuators (DHLAs), designed for this purpose. By rotating the fixed end of a double-helix linear actuator, its helix angle changes, displacing at the free end. This article proposes two concepts for DHLA designs, differing in their supporting structure, and derives kinematic and geometric models for both. Prototypes of each concept are presented, and for the more promising "continuous-rails" design, hardware tests are conducted that validate the actuator's kinematic model and characterize its force transmission properties. The final prototypes can exert both tension and compression forces, can displace up to 75% of their total length, and show consistent trends for torque versus force load. These designs have the potential to overcome the force and displacement limitations of other linear actuators while simultaneously reducing size and weight.

Breakdown:

Many robotic systems require linear actuation with high forces, large displacements, and compact profiles.
^^ (1)-(2) Problem statement. You're reading this journal because you agree that robots are important. But we could always use better robot designs, especially linear actuators.

This article presents a series of mechanisms, termed double-helix linear actuators (DHLAs), designed for this purpose.
^^ (3) Our contribution.

By rotating the fixed end of a double-helix linear actuator, its helix angle changes, displacing at the free end.
^^ (3)-(4) Insight that made this work possible, with technical specifics.

This article proposes two concepts for DHLA designs, differing in their supporting structure, and derives kinematic and geometric models for both.
^^ (5) we did some modeling to tell us if they're good ideas or not.

Prototypes of each concept are presented, and for the more promising "continuous-rails" design, hardware tests are conducted that validate the actuator's kinematic model and characterize its force transmission properties.

^^ (5) one of the ideas was better. We did hardware tests in order to confirm its response versus our simulations.

The final prototypes can exert both tension and compression forces, can displace up to 75% of their total length, and show consistent trends for torque versus force load.
^^ (6) the results had really excellent numbers.

These designs have the potential to overcome the force and displacement limitations of other linear actuators while simultaneously reducing size and weight.
^^ (7) wow isn't this great! You should try it out also, or cite our paper.

3. *Liquid Crystal Elastomer with Integrated Soft Thermoelectrics for Shape Memory Actuation and Energy Harvesting*
    a. application result example, no theory or simulations.
    b. https://onlinelibrary.wiley.com/doi/full/10.1002/adma.202200857

<u>Abstract:</u>

Liquid crystal elastomers (LCEs) have attracted tremendous interest as actuators for soft robotics due to their mechanical and shape memory properties. However, LCE actuators typically respond to thermal stimulation through active Joule heating and passive cooling, which make them difficult to control. In this work, LCEs are combined with soft, stretchable thermoelectrics to create transducers capable of electrically controlled actuation, active cooling, and thermal-to-electrical energy conversion. The thermoelectric layers are composed of semiconductors embedded within a 3D printed elastomer matrix and wired together with eutectic gallium–indium (EGaIn) liquid metal interconnects. This layer is covered on both sides with LCE, which alternately heats and cools to achieve cyclical bending actuation in response to voltage-controlled Peltier activation. Moreover, the thermoelectric layer can harvest energy from thermal gradients between the two LCE layers through the Seebeck effect, allowing for regenerative energy harvesting. As demonstrations, first, closed-loop control of the transducer is performed to rapidly track a changing actuator position. Second, a soft robotic walker that is capable of walking toward a heat source and harvesting energy is introduced. Lastly, phototropic-inspired autonomous deflection of the limbs toward a heat source is shown, demonstrating an additional method to increase energy recuperation efficiency for soft systems.

<u>Breakdown:</u>

Liquid crystal elastomers (LCEs) have attracted tremendous interest as actuators for soft robotics due to their mechanical and shape memory properties.
^^ (1) You're reading a soft materials journal so you agree that soft materials are important. This particular type of soft materials could be really good at robot things.

However, LCE actuators typically respond to thermal stimulation through active Joule heating and passive cooling, which make them difficult to control.
^^ (2) however, these super excellent materials have a problem, which is that we can't make them move very fast: we have to wait until they cool down.

In this work, LCEs are combined with soft, stretchable thermoelectrics to create transducers capable of electrically controlled actuation, active cooling, and thermal-to-electrical energy conversion.
^^ (3) Our contribution was to combine "A" with "B". When we do so, we can cool down the fancy material also.

The thermoelectric layers are composed of semiconductors embedded within a 3D printed elastomer matrix and wired together with eutectic gallium–indium (EGaIn) liquid metal interconnects.
^^ (4) Our technical solution uses liquid metal, plus some other stuff, to do the thermoelectric part. (Note, I didn't write this abstract: here, I would have also included a "why this is better/different than before," for example, "...integrating thermally-responsive semiconductors into a soft material for the first time.)

This layer is covered on both sides with LCE, which alternately heats and cools to achieve cyclical bending actuation in response to voltage-controlled Peltier activation.
^^ (4) Here's the engineering/scientific reason why "A" plus "B" solves the problem.

Moreover, the thermoelectric layer can harvest energy from thermal gradients between the two LCE layers through the Seebeck effect, allowing for regenerative energy harvesting.
^^ (4) our contribution also addresses the limitations from sentence #1 by using the same design but operated in reverse.

As demonstrations, first, closed-loop control of the transducer is performed to rapidly track a changing actuator position.
^^ (5)-(6) we showed it working proof–of-concept in application #1, and it worked the way we expected.

Second, a soft robotic walker that is capable of walking toward a heat source and harvesting energy is introduced.
^^ (5)-(6) we showed it working proof–of-concept in application #2, and it worked the way we expected..

Lastly, phototropic-inspired autonomous deflection of the limbs toward a heat source is shown, demonstrating an additional method to increase energy recuperation efficiency for soft systems.
^^ (5)-(6) we showed it working proof–of-concept in application #3, and it worked the way we expected.
^^ bonus: (7) is by emphasizing "energy recuperation efficiency for soft systems."

4. *A Comparison of Mechanics Simplifications in Pose Estimation For Thermally-Actuated Soft Robot Limbs*
    a. small result example: “it didn’t work the way we hoped, but we’re publishing something anyway”
    b. [insert link to arXiv]

Abstract:

Soft robots can be limited in applications when their pose in space is difficult to estimate, particularly when actuated by smart thermoelectric materials with difficult-to-model mechanics. This paper presents a comparative study of approximations and simplifications that could make pose estimation computationally practical in real-world settings. To do so, this article represents a planar soft robot arm as a discretized many-link rigid arm, mapping material stiffness and actuator states to torques at the robot's joints. Four different sets of assumptions are proposed for these mappings, varying in how stiffness is distributed throughout the arm, as well the linearity and/or hystersis of the actuator torques. We demonstrate how to calibrate each model from experimental data in a soft arm powered by shape memory alloy (SMA) wires that contract via Joule heating. Then, we perform hardware tests to predict the robot's pose in open-loop, using only actuator temperature, and compare model performance under each simplifying assumption. Results show that adding both nonlinearity and hysteresis to the actuator model improves the pose predictions, and that open challenges remain in calibrating material parameters. This study provides a platform and an initial result toward real-time pose estimation of these robots.

Breakdown:

Soft robots can be limited in applications when their pose in space is difficult to estimate, particularly when actuated by smart thermoelectric materials with difficult-to-model mechanics.
^^ (1)-(2) You’re reading this at a smart materials and intelligent systems conference, so you’re good for soft robots. But to use them, gotta know their position in space, and that’s hard right now when smart materials are used as actuators.

This paper presents a comparative study of approximations and simplifications that could make pose estimation computationally practical in real-world settings.
^^ (3) Our contribution is to compare approaches that could be used to address this gap.

To do so, this article represents a planar soft robot arm as a discretized many-link rigid arm, mapping material stiffness and actuator states to torques at the robot's joints.
^^ (4) We do that comparison with a simple model of the robot’s body and actuator, to isolate where the difficult parts could come in and mess up the models.

Four different sets of assumptions are proposed for these mappings, varying in how stiffness is distributed throughout the arm, as well the linearity and/or hystersis of the actuator torques.
^^ (5) Our comparison varied these particular things we thought were important.

We demonstrate how to calibrate each model from experimental data in a soft arm powered by shape memory alloy (SMA) wires that contract via Joule heating.
^^ (5) We tried out each assumption on the same piece of hardware, showing how you'd do that from data.

Then, we perform hardware tests to predict the robot's pose in open-loop, using only actuator temperature, and compare model performance under each simplifying assumption.
^^ (5) The big test was trying out each method predicting a new motion using old data.

Results show that adding both nonlinearity and hystersis to the actuator model improves the pose predictions, and that open challenges remain in calibrating material parameters.
^^ (6) Some of the models were better than others and it showed us that phenomena X, Y, and Z cannot be ignored, because the results were really bad without them.

This study provides a platform and an initial result toward real-time pose estimation of these robots.
^^ (7) We got some insights here, so even though it didn't work how we expected, it's useful for other people to know about. And the test setup could be reused when we (or you!) do the math differently.