Enter Project Title Here

Submission date: Click or tap to enter a date.

Please replace all explanatory text when completing this proposal.

1. **Participants**

Please list your team’s participating researchers, beginning with the principal investigator.

|  |  |  |
| --- | --- | --- |
| **Name** | **Affiliation** | **Email Address** |
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1. **Project Abstract**

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| **Research Vector:** Choose an item. |
| Brief description of the project’s goal, scope, and impact. (Not more than a few sentences.) |

1. **Project Description**

Please write a 1-2 page project description covering the following aspects:

* What problem will this project attempt to solve, with respect to the current state-of-the-art?
* What approach and methods do you expect to apply?
* How does your approach compare to prior work?
* Relate your approach to other past/present work by the participants. Why do you expect this team to succeed?
* What unique value does the Loihi architecture (and/or neuromorphic hardware in general) offer for this solution?
* How will you quantitatively evaluate the results in relation to prior work?
* Define success for this project and describe the impact of a successful outcome.
* Include citations to past related work.

For RV2 (algorithms) research proposals, please complete the Algorithm Assessment (Section 10) to provide further specific details about the motivation and aims of the project. For RV3 (applications) proposals, please complete the Application Assessment (Section 11).

1. **Research Plan**

Describe your research plan. Include:

* Deliverables (e.g. papers, seminars, code enhancements or new INRC modules, physical systems you expect to build.)
* Personnel (Who will do what?)
* Milestones (key events that indicate progress), with targeted completion dates.
* Technical tradeoffs that may have to be made
1. **Loihi Resource Needs**

[ ]  Project will require on-site use of physical Loihi systems

[ ]  Project specifically targets Loihi 2 capabilities

Please indicate your Loihi system needs:

* Size of networks your project will prototype, in expected number of chips.
* What Loihi cloud development resources do you foresee needing? For example, will occasional access to a single Loihi system suffice over the duration of the project to validate analytical models, or will you expect to continuously run many concurrent instances of your networks for hyperparameter optimization purposes?
* Describe and justify your need for physical Loihi systems and/or chips.
1. **Material Deliverables**

Please describe what you specifically expect to contribute to the INRC for common use. These will often include the following:

* Software modules or code enhancements contributed to a Lava GitHub repository, or some other publicly available software repository.
* Papers, tutorials, and seminars that allow other INRC members to replicate and apply your findings.
* New datasets and benchmarking methodologies

1. **Intellectional Property**

In general, we hope each INRC member will freely share the intellectual property they create through their work as part of the research community for other INRC members’ use, and to the public domain in general. We understand this is not always possible for corporate members.

In this section, please detail your plans for IP ownership any background IP restrictions. Establishing clear and fair intellectual property rights is essential for INRC access. These matters will be resolved with your organization’s technology transfer office or legal department.

Please note that any academic project that receives Intel funding will be required to contribute all IP created as part of the project to the public domain as a condition for selection.

1. **Administrative Matters**

Include a statement stipulating that Intel will be able to internally evaluate any software prototypes developed during the research.

Include the following administrative information for yourself and any co-investigators:

* Researcher's Name: first and last name, title.
* Researcher's Organization: university or laboratory name, home page.
* Researcher's Department: department name, home page.
* Researcher’s Contact: address, phone, email, personal or project home page.
* Researcher’s Nationality: needed for export control compliance purposes.
* University Foundation, Technology Development Office, or Legal Contact authorized to process grant and intellectual property issues: address, phone, email.
1. **Submission Process**

Please submit an electronic copy of your proposal and any questions you may have on the submission process to the following email address:

INRC\_Project\_Proposals@intel.com

You will receive an email from Intel Labs acknowledging the receipt of your proposal within 3 business days.

1. **Neuromorphic Algorithm Assessment (RV2 projects)**

**Algorithm definition**

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| What computational problem does the proposed algorithm solve? |
| *Ideally, this is a clear mathematical objective.* |
| What learning paradigms are involved, if any? |
| *Examples: Supervised (online or offline?), self-supervised, unsupervised, reinforcement-based, associative, gradient-based adaptation, continual.* |
| What are the algorithm’s essential “neuromorphic” properties? |
| *Examples: Temporal neuron models, binary activations, sparse spike/event-based communication, sparse connectivity, recurrence, E/I balance, parameter plasticity, structural plasticity, fully local synaptic & neural information processing, distributed data representations.* |
| Are data input/output interfaces and encodings well defined? |
| *Does the algorithm operate on conventional data types, or spiking/event-based data types? Does it process time series data streams with temporal structure (e.g. video), or isolated, uncorrelated samples (e.g. images)?* |
| How far towards a deployable neuromorphic solution will the proposed algorithmic research be taken? |
| *Is the aim to develop software that executes the algorithm on Loihi to process real-world data? Or is the goal a simulation-based demonstration believed to be compatible with Loihi HW? Something in between?* |

**Potential Value**

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| How broadly applicable is the proposed algorithm? |
| *What real-world capabilities, applications, and technologies could this algorithm be used in?* |
| Characterize the difficulty of the problem to be solved. |
| *E.g. NP-complete/hard, existing state-of-the-art DNN network scale, typical Energy-Delay-Product application constraints, typical CPU runtime, etc.* |
| What value does a neuromorphic solution promise? |
| *Does the algorithm primarily improve the energy, speed, or data efficiency of existing algorithms? Or is there no known conventional solution?* |
| What can be said about the algorithm’s modularity and composability? |
| *Can the algorithm be integrated into a larger application where the whole is greater than the sum of its parts?* |
| How mature is the proposed algorithmic approach? |
| *Are the key algorithmic or implementation ingredients understood or is it part of this proposal to develop such an understanding? What are the key open questions and risks? Do conventional ANN implementations exist?* |
| At what problem scale is the algorithm expected to be demonstrated? |
| *What scale will be demonstrated relative to the scale demanded by useful and impactful real-world applications? (In terms of physical metrics like I/O dimensionality, #parameters, #neurons, dataset size, stored patterns/classes, etc.)* |

**Implementation Requirements**

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| What requirements does the algorithm impose on the Lava SW infrastructure or other algorithms? |
| *What infrastructure is expected to exist (or when will it need to exist)? Are there critical requirements on data input/output encodings or bandwidth?* |
| What can be said about the specific features and numeric precision required of the neuromorphic hardware? |
| *Note: Loihi 2’s synaptic variables provide up to 8 bits, while neural variables offer 8, 16 or 24 bits of (un)signed integer precision.* |
| Does the algorithm require on-chip synaptic plasticity? |
|  *If so, are the learning rules supported by Loihi’s micro-code programmable learning engine, if known?* |
| Does the algorithm currently depend on features not supported by Loihi 2? |
| *(If known) Examples: division or transcendental functions applied to neuron/synaptic state changes, non-local weight normalization or transport.* |

**Proposed Approach**

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| What methodology is being followed to develop this algorithm? |
| *Is the proposed algorithm from the category of mathematically derived algorithms or directly inspired by neuroscience modeling?* |
| What software tools will be used to develop the algorithm? |
| *E.g. Lava, Brian, Nengo, Matlab, directly coded Python/C++, TensorFlow, PyTorch, SLAYER, SpyTorch, Fugu, etc.* |
| How is the algorithm or initial neural network configured, parameterized, or trained? |
| *Does it rely on pre-training with back-propagation, manual parameter tuning, evolutionary methods or is the network configuration computed analytically?* |
| Does the algorithm involve continual online learning? If so, how? |
| *Is new knowledge absorbed into existing resources or reliant on allocating new memory resources over time? How is forgetting mitigated? Does learning rely on assumptions of IID input data?* |
| What neuron model(s) will be used? |
| *E.g. LIF, ALIF, CUBA, COBA, ReLU, Resonate-and-fire, Izhikevich, GLM, etc.* |
| How is data coded in the network? |
| *E.g. spike-based or integer-valued events, temporal coding, rate coding, population coding, mixtures thereof.* |

**Evaluation Methodology**

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| How will the performance of the algorithm be evaluated? |
| *What are the critical performance metrics? Will standardized benchmarks, datasets, simulation environments, etc. be used? If so, please list them. If not, how will performance be quantified in a replicatable manner?* |
| What competitive state-of-the-art conventional and neuromorphic solutions exist today, if any, and what HW platforms do they run on? |
| *Which of the current solutions are state-of-the-art with respect to the metrics/benchmarks above? Does the proposer have access to a working reference implementation of any of these competitive algorithms?* |
| What are the limitations or major pain points of current solutions? |
| *In what way are current solutions inadequate? Are they failing to meet real-world application needs in terms of key metrics?* |

1. **Neuromorphic Application Assessment (RV3 projects)**

**Application definition**

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| What is the task? |
| *Please provide a concise high-level description of the application.* *Are there any references to learn more about the task?* |
| What are the key computationally hard components of the task? |
| *Examples might be DNNs, ML algorithms, standard optimization objectives (LASSO, QUBO, MLIP, graph search, etc.) What proportion of the task’s hard computational components will be solved neuromorphically?* |

**Potential Value**

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| What is the impact of solving the task? |
| *Articulate in terms of value to the end user/customer. Why will anyone care that this task is successfully accomplished?* |
| Is there already an existing market or a path to commercialization for this application? |
| *Who are the customers? What is the path to commercialization? Any obstacles or recent enabling developments? What is the size of an existing market?* |
| How generalizable or broadly applicable is a solution to this task? |
| *How easy is it to generalize the task to other domains?**What else could a superior implementation to components of the task be applied to?* |

**Implementation Requirements**

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| What are the key metrics to assess the performance or quality of this task? |
| *Examples could be energy or time to solution, accuracy or result with respect to some reference, area, cost.* |
| Are there critical data IO, throughput, latency, closed-loop requirements? |
| *Providing quantitative requirements will help us determine if available Loihi systems can possibly suffice.* |
| Are there requirements on setup time? |
| *Setup time may include compiling a program or model, loading it onto a HW platform.**If the application is typically launched once and executed for a long time, then the answer is likely no. If otherwise, please explain.* |
| What degree of programmability or flexibility is required by the HW compute platform? |
| *Does the task require the flexibility of a general-purpose CPU to maximize developer productivity or satisfy other constraints or is the task best served by a custom ASIC – or something in-between?* |
| Does the task require any real-time adaptation? |
| *Is the program or model entirely pre-configured or pre-trained before deployment or does it have to adapt after deployment by itself based on data? What type of adaptation is required? Backpropagation or other learning rules?* |

**Proposed Approach**

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| What neuromorphic methods will be used to solve the task? |
| *What algorithms, software, and other critical neuromorphic ingredients will be used? Please provide references wherever possible.* |
| How mature are these methods; what exists today versus what needs to be invented/proven? |
| *Have the necessary algorithms been modeled successfully to date? Have they been mapped to neuromorphic hardware and shown to work at the scale demanded by the application? Have all application precision requirements been considered? Do the relevant Lava software modules exist today? Are the modules interoperable/composable?* |

**State-of-the-art Alternatives**

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| What competitive state-of-the-art solutions exist today, if any? |
| *What are the critical performance metrics? In what way are current solutions state of the art with respect to those metrics? Does the proposer have access to a working reference implementation to the problem based on conventional systems?* |
| What are the limitations or major pain points of current solutions? |
| *How and why are they insufficient? In what way do current solutions not address the desired key metric requirements?* |
| How will the neuromorphic solution be evaluated against other solutions?  |
| *Are there standardized benchmarks to evaluate the proposed solution versus state-of-the-art alternatives?* *If so, please describe and provide references if possible. If not, how will success be defined?* |

**Intel Labs Corporate University Research Office (CUR)**

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**[ ]** Check here to certify that you are not engaged in prior agreements (e.g. government contracts) that constraint your ability to negotiate mutually agreeable intellectual property terms for this grant

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| **Proposal Title:**  |
|  |
| **University Name / Receiving Organization** | **Department/Discipline** |
|  |  |
| **Representative Authorized****To Conduct Grant Administration** | **Principal Investigator Information** |
| **Contact Name** |       | **PI Name** |  |
| **Mailing Address** |       | **Mailing Address** |  |
| **Phone #** |       | **Phone #** |  |
| **Fax #** |  | **Fax #** |  |
| **E-Mail Address** |  | **E-Mail Address** |  |
| **Amount of Cash Requested** | **USD $** | **Project /PI URL**  |  |
| **Co-Investigator/Students**  |  |
| **Project Duration** | **months**  | **Includes Overhead? Y/N** |  |
| **Additional Comments:** |       |

**Please also attach a complete cost volume analysis in support of the amount of cash requested above.**