1. A concise description of the project

According to the National Nanotech Initiative nanotechnology represents "research and technology development at the atomic, molecular or macromolecular scale leading to the controlled creation and use of structures, devices and systems with a length scale of approximately 1 – 100 nanometers (nm)." It can be used in a variety of consumer products including clothing, wound dressings, sunglasses, sunscreens, cosmetics, sporting equipment, and structural materials.

The definition of nanoparticles is that one characteristic dimension measures 100 nanometers or less. Nanoparticles represent essentially very small pieces of material. When formed into nanoparticles, the properties of many conventional materials change. This is typically because nanoparticles have a greater surface area per weight than larger particles which causes them to be more reactive to other molecules.

Nanoparticles are used, or being evaluated for use, in many fields such as: 1) Medicine (enable dual functionality as they can be used for diagnostic and therapeutic purposes, target tumors - can be used to reduce toxicity of a therapeutic drug, perform robotic tasks - nanorobots can be used for drug release, etc.); 2) Manufacturing and Materials; 3) Environment; 4) Energy and Electronics; 5) Lighting; 6) Air Conditioning; 7) Perfumes; 8) Solar Panels; 9) Pharmaceutic Manufacturing; 10) Automobile Industry; etc.

Nanoparticles can be engineered with distinctive composition, size, shape, and surface chemistry to enable novel techniques in a wide range of applications. Morphology control on the nanoscale is a hot topic because of the spectacular effects that small changes in the shape of nanoparticles have on a variety of physical properties of the material such as optical, magnetic, electronic, etc. Current characterization of nanostructures and their morphology analysis is labor and computation intensive. This is why automatic assessment to nanostructure analysis and automated approach to its characterization is essential for nanotechnology and nano-manufacturing. Digital image processing methods and techniques can greatly improve the quantification of nanostructure local variability with minimum metrology and time consuming efforts. Image processing approaches and algorithms represent a convenient and practical tool to observe and analyze nanostructures quantitatively and qualitatively. Nanoparticles' distinctive composition, size, shape, and surface chemistry defines their potential wide range of applications. Also, small changes in the shape of nanoparticles have a great influence on a variety of physical properties of the material which makes nanoscale morphology control a very important aspect of nanotechnology. Convenient automated image processing method for efficient and accurate nanoparticle characterization and measurements can greatly contribute to this area.

When processed into nanoparticles, the properties of many conventional organic and inorganic materials change. Since nanoparticles can be made from organic or inorganic substances, they are versatile in potential technological applications, from delicate electronics to revolutionary medical procedures. While an average structure and size is clear from characterization measurements and observations there is always a dispersity in size and shape of the final nanoparticle system. Even though microscopy is an excellent technique in capturing direct images of the nanoparticle morphology, it is difficult to assess the dispersity in size and shape of the nanostructure simply by observation of the microscopy data.

The properties of conventional materials change due to confinement into nanoparticles. Since nanoparticles can be particles from any substance, they are versatile enough that they can be used in wide range of technological applications which makes them very popular in modern technology. Even though microscopy is an excellent technique in capturing direct images of the nanoparticle morphology, it is difficult to assess the dispersity in size and shape of the nanostructure simply by observation of the microscopy data. It is critical to expand capabilities of existing tools focusing on automated nanoparticle detection. This is why we plan to develop a computer assisted tool for the purpose of facilitated nanoparticle detection and its morphology identification.

2. Measurable goals and objectives for the project

GOAL: Provide an automated approach to nanostructure characterization and analysis.

OBJECTIVE: Design an intelligent software to facilitate nanoparticle detection and its morphology identification.

3. The timeframe for the project

Phase I:

June 2026 - July 2026 - Research collaboration with Prof. Dr. Pedro Mayorga, Professor at the Instituto Tecnológico de Mexicali, Mexicali B.C., México. I will involve and train in the research two Lincoln students during summer and write a research paper on this topic that I intend to publish.

4. How the project will enhance teaching/learning at Lincoln University

This research will involve two Lincoln students and Engineering Science, Chemistry, Physics and Biology/PreMed major students from the Lincoln University can benefit from this research on whole as they will be exposed to the latest research achievements in this biomedical engineering interdisciplinary field. This will be very advantageous to them as minority students in STEM.

5. The number of people who will benefit, and how

About 5 students pursuing Engineering Science, Chemistry, Physics and Biology/PreMed majors from the Lincoln University will multiply benefit from this project. The students will benefit through educational aspect, being directly involved in the research.

6. How the success of the project will be measured

The success of the project will be measured multiply through:

a) Successful presentation of the research results,
b) Continued collaboration with the Instituto Tecnológico de Mexicali, Mexicali B.C., México.

7. How, when, where, and with whom the project's outcome will be shared

The research results will be presented and discussed in the Center for Excellence in Teaching and Learning, at the Faculty Symposium, at the Chemistry and Physics Departmental meeting and the workshop will be organized for all the Lincoln University students and faculty members. A summary report of the project will be sent to the Chair of Faculty Research and Development Committee.