CASE WESTERN RESERVE UNIVERSITY EST. 1826

Department of Materials Science and Engineering
10900 Euclid Ave., White Bldg, Rm 312
Cleveland, OH
Tel: 216-368-1987

12/05/2016

Dear Nord Grant Committee members,

We propose introduction of holographic teaching in Materials Science classes, specifically with initial focus on crystallography. Establishing augmented reality based lectures provide a new tool to enhance the learning experience of the students. Holographic teaching enables the instructors to convey complicated three dimensional concepts without the limitations of lower dimensional medium. HoloLens and augmented reality based teaching has been the focus of the university as they establish the latest technologies in the Health Education Campus build by Case Western Reserve University and Cleveland Clinic. As this new technology defines the future of education, its applicability extends far beyond medical training. The PI proposes incremental introduction of the augmented reality based teaching as an early adoptor into the School of Engineering. The proposed purchase of two HoloLens' will be the seed coupled with the current investment of the PI on development of the related software. This proposal benefits the university as it clearly fits to the current direction and extends it beyond the present medical focus; it benefits the PI as an instructor to build the educational component of his career in becoming an expert in teaching via augmented reality and it benefits the students as their education is enriched by the effective instruction of complicated concepts.

Microsoft HoloLens is a pioneering, augmented-reality headset device that projects holograms. Unlike other virtual-reality devices, this lightweight, wireless headset with a transparent visor allows wearers to see and hear the people and objects in the real world – providing an augmented reality or "mixed-reality" experience that blends the real world with the virtual world. With HoloLens, one can make holograms appear on a desk or transform a classroom into what feels like the surface of Mars. Students and teachers can wear the devices and interact together as they view the same hologram as if it was an object in the room, or students can wear the device for study or distance learning.

The broader impact of the teaching in augmented reality space is its applicability to numerous topics, schools and departments. The investment will only grow as the success of holographic teaching is established through these early adoptions. Thus, this Nord Grant, if granted, can lead to a profound impact towards the future of education at Case Western Reserve University. The initial step by the PI will be teaching crystallography through the augmented medium. Crystallography is fundamental to understanding the behavior of materials as well as to discovery of how they enable engineering of new applications. Therefore, it is a part of several classes in the department and school of engineering at varying levels ranging from introductory (e.g. ENGR 145, EMSE 276) to advanced (e.g. EMSE 328).

The PI has observed the limitations of regular teaching media for introducing crystallography. It can be difficult to convey information about complicated crystal structures in two-dimensional media. In general, symmetry has been defined by using elements such as mirror planes, inversion centers, and n-fold rotation axes and their combinations creating 32 point groups, which define all the inorganic material structures. These can be expanded further into 230 space groups through introduction of glide- and screw-symmetries. In addition to the local unit-cell symmetry, higher-order symmetry can exist in formation of superlattices and due to relative motion of

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structure-building units (e.g., octahedra) which can be categorized using different notations (e.g., Glazer's notation). Currently and traditionally, the instructors use 2D stereographic projections to teach complicated 3D symmetry operations. PI's experience has been that a great number of students (even the ones who grasp the operations at this dimensionally reduced space) struggle to apply what they learn to real 3D space. In order to solve this problem, the PI has recently started designing an app on crystallography that will allow introduction of HoloLens to teach in 3D. Beyond the education domain, this application will also allow researchers to visualize their own material systems, interfaces, phase transformations and defect structures.

The degree of utilization of Hololens in the classroom depends on the class size, classroom design and the availability of the Hololens. This proposal is for purchasing of two HoloLens' to be used by the instructor in the classroom and together with students at office hours. At this stage due to limited number of HoloLens', the implementation in the classroom will be done by using the live streaming ability of the HoloLens. The instructor will wear the Hololens and project his view on to the screen for all the students to watch. Students will also be able to directly watch it from their laptops wherever they are located (i.e, in the classroom, or another country). In addition, in office hours students will have an opportunity to wear the HoloLens to create the crystal structures, implement symmetry operations and walk around the 3D holograms to observe the structures and develop a better understanding of crystallography. The instructor will wear the second HoloLens and discuss and work on the same hologram with the student; essentially lecturing one to one on the augmented space. This one to one interaction provides further insight to the topic of interest and answer to the student's questions.

The PI has already been working with a graduate Computer Science student and computer programmers at Interactive Commons to create an app that allows introduction of: (i) point groups for novice learners where the users can choose a crystal system, a point group, and positions for select atoms per formula unit and apply the symmetry elements to create all the atoms in the unit cell, as well as to image each symmetry element separately. A floating periodic table allows the user to replace cations and anions using real ionic radius and coordination number data, (ii) space groups for advanced users where users can introduce elements from international crystallography tables and image complicated structures. They will have the ability to fuse a defined number of unit cells in 3D and cut the structure with planes in any angle to show co-planar atoms.

In the classes where the Holographic teaching is employed, students input will be used to evaluate (i) the user interface of the app, (ii) its implementation in the class, and (iii) how it can be of further use to the students. Topics of materials science such as phase transformations, defect chemistry, diffusion, multi-scale structure (from atomic to micron-scale), transport properties and fracture mechanics can all benefit from teaching in 3D. Therefore, this initial proposal can have a much greater impact in the future for interactive 3D teaching.

The proposed budget for Nord Grant Program covers purchase of two HoloLens' at $6,000. With the success of this implementation, the benefit can further be extended beyond the department and the university can have enough data to justify a greater investment in extending Holographic teaching and build technologically supported classrooms.

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Proposed budget:

TITLE: Introduction of Holographic teaching into Materials Science Classes

PERIOD: 1/1/17-12/31/17

P.I. : Alp Sehirlioglu

Sponsor: CWRU Internal Nord Grant

				FY18	
				7/1/2017	
				Year 1	**TOTAL**
SALARY:					
PI	Sehirlioglu	0%			0.0
					0.0
		SUB-TOTAL		0	0
	FRINGE BENEFITS		27.50%	0	0
	SALARY & FRINGE BENEFITS TOTAL			0	0
NON-SALARY:					
536000	Minor Equipment			6,000	6,000
		SUB-TOTAL		6,000	6,000
	MTDC			*0.0*	0
	Total Direct Costs			6,000	6,000
	Indirect Costs		58.50%	0	0
	Total			6,000	6,000

Title & Amount of prior Nord Grants received: No Prior Nord Grants

Department Approval:

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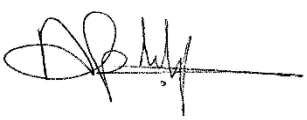
Sincerely,

Alp Sehirlioglu, Ph.D.
Warren E. Rupp Asst. Prof.
Department of Materials Science and Engineering



Frank Ernst, Ph.D.
Department Chair and Leonard Case Jr. Professor of Engineering
Department of Materials Science and Engineering