

Acquisition of a 3D digital image correlation (DIC) system

Proposal Team

PI: Dr. Ankit Saxena, Assistant Professor of Mechanical Engineering

Co-PIs: Dr. Xiang Zhang, Assistant Professor of Mechanical Engineering, and Dr. Daniel Rau, Assistant Professor of Mechanical Engineering

Equipment Details

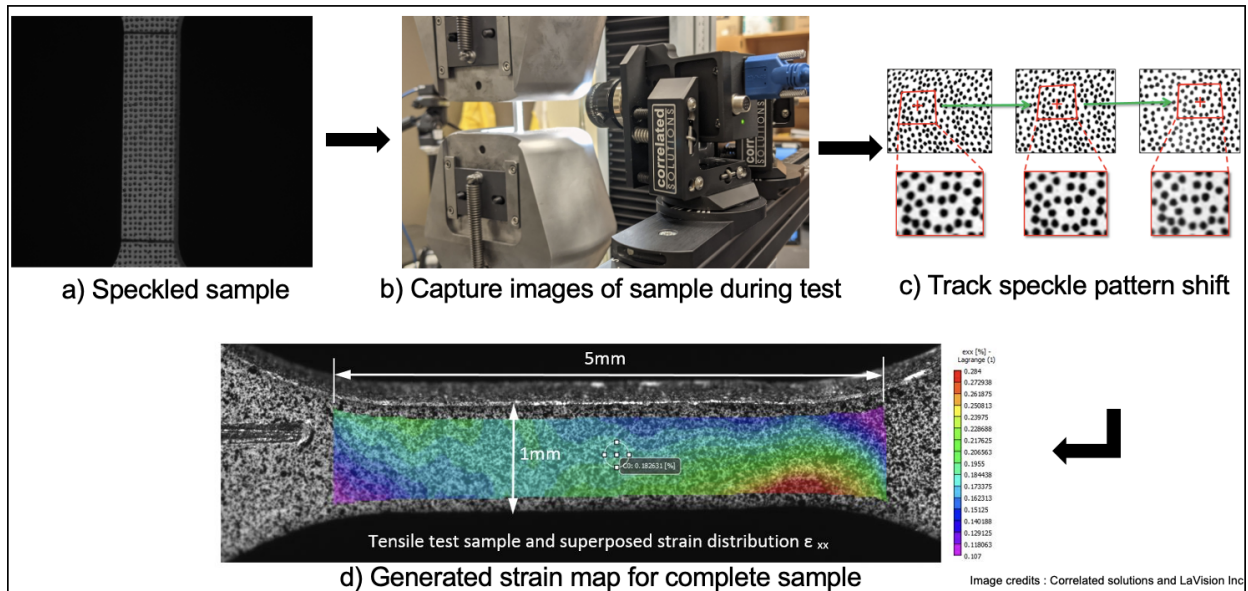


Figure 1: Digital image correlation overview

This proposal requests \$79,598.25 to purchase a turnkey 3D Digital Image Correlation (DIC) System, enhancing the material science research capabilities in the College of Engineering and Physical Sciences (CEPS). DIC is a state-of-the-art deformation and strain measurement technique used to characterize the mechanical properties of various engineering materials such as metals, polymers, ceramics, concrete, etc. 3D DIC systems use two cameras to view the surface of a material testing specimen that is speckled with small dots (Figure 1a). During a material testing experiment, the cameras acquire a series of images (Figure 1b) which are later analyzed by tracking the speckle pattern shift over the entire surface (Figure 1c). The change in the speckle pattern (Figure 1d) gives the deformation and strain that are required in a large majority of mechanical characterization experiments [1].

Currently, the ME department has more than 10 mechanical characterization machines that will be instantly upgraded by the acquisition of the DIC system. This is because tripod-mounted DIC cameras can be easily moved from machine to machine. Notable mechanical characterization machines include 7 load frames, 2 dynamic mechanical analyzers, and one linear actuator that can be used for a variety of static and dynamic mechanical characterization experiments. The DIC system includes a lifetime software license and technical support contract that ensures that the system is usable by current and future faculty in the CEPS. There will be no recurring maintenance and licensing costs associated with the system. The DIC system will be managed by PI Saxena and will be housed in his research lab (EN 2042).

The proposal team has significant experience using DIC systems and several journal articles have been published by Saxena[2, 3] and Zhang [4, 5]. Due to the limitation of strain measurement

tools at UW, the proposal team collaborated with researchers at other universities that owned DIC systems. Thus, having a DIC system at UW will significantly increase the material science research capabilities of the proposal team and the CEPS as a whole.

Alignment With Goals Of The Tier-1 Engineering Initiative

1. World-Class Research And Graduate Education

The ME department has a long-standing reputation for cutting-edge material science research. With two new tenure track faculty, Saxena and Rau, and a well-established material research group led by Zhang, the demand for state-of-the-art material science equipment is very high. The proposal team is involved in researching a wide range of materials such as soft polymers being developed by co-PI Rau [6], 3D printed titanium samples being investigated by co-PI Zhang, and adaptive stiffness meta-materials being developed by PI Saxena [7]. The application domains include energy research (hydrogen, nuclear, and wind), medical devices, aerospace structures, and adaptive materials and structures. The proposal team has a combined total of more than eight proposals pending or in development that will directly benefit from this acquisition. Due to the broad application scope of the DIC, the team anticipates a sustained demand for the system and is confident that multiple grant awards and dissertations will evolve from this acquisition enabling sustained scholarly contributions to engineering research. Additionally, co-PI Zhang teaches the graduate course ME 5472 *Continuum Mechanics* where students write Matlab codes to extract strain fields from DIC images. This equipment will allow the students to take the DIC images by themselves as part of the course project and further enhance their understanding and skills on DIC.

2. Excellence In Undergraduate Education

PI Saxena is the instructor for the two required material science courses in the ME department, ME 3450 *Properties of Materials* and ME 4150 *Mechanical Behavior of Materials*. Both courses cover material characterization techniques such as tension and bending tests, fatigue testing, etc. Existing teaching resources include outdated strain measurement techniques such as strain gauges. The DIC system will enhance our existing teaching resources ensuring that students have access to a state-of-the-art learning environment. Similarly, Co-PI Rau teaches ME 3010 *Intermediate Mechanics of Materials* where he will integrate practical demonstrations of DIC to bolster the fundamental concepts that form the basis for DIC that he teaches in this course.

3. K-14 Stem Education

PI Saxena is closely working with Dr. Cindy Jones, (Assistant Dean for Student Success and K-14 Outreach Director, CEPS, UW) and Hannah DiRienzo (Engineering and math instructor, Laramie High School) to establish a sustained education program focussing on material science research and its real-world applications. The program will introduce high school students to the exciting world of destructive material testing that combines the fun of breaking things with cutting-edge material science research. Students will get to break test samples and the DIC system will be used to make slow-motion videos of material failure, showing advanced concepts such as crack formation and propagation. Such activities are not possible without high-resolution DIC cameras capturing minute details that cannot be observed through the naked eye. Similarly, co-PI Rau is developing outreach focused primarily on additive manufacturing with high school students in the Laramie public school system with hands-on activities planned for printing soft materials. The DIC system will be used to study how these soft materials stretch tremendously and then break, providing an exciting and engaging demonstration.

References Cited

- [1] H. B. Motra, J. Hildebrand, and A. Dimmig-Osburg, “Assessment of strain measurement techniques to characterise mechanical properties of structural steel,” vol. 17, no. 4, pp. 260–269.
- [2] A. Shaikh, J. Griffis, R. Stebbins, K. Safowan Shahed, A. Saxena, A. Ross, and G. Manogharan, “Towards gradient design of TPMS lattices and laser powder bed fusion processing– role of laser strategies and lattice thickness,” vol. 41, pp. 1046–1054.
- [3] A. Shaikh, A. Saxena, J. Griffis, K. Shahed, and G. Manogharan, “Functionally graded TPMS gyroid structures for additive manufacturing of non-pneumatic tires,” vol. 3, no. 4, p. 5022. Number: 4 Publisher: AccScience Publishing.
- [4] Z. Chen, B. Koohbor, X. Zhang, L. M. Dean, P. H. Geubelle, and N. R. Sottos, “Residual strain development in rapid frontally curing polymers,” vol. 2, no. 11, pp. 2597–2607.
- [5] J. Benzing, Y. Liu, X. Zhang, W. Luecke, D. Ponge, A. Dutta, C. Oskay, D. Raabe, and J. Wittig, “Experimental and numerical study of mechanical properties of multi-phase medium-mn TWIP-TRIP steel: Influences of strain rate and phase constituents,” vol. 177, pp. 250–265.
- [6] D. Rau, M. Kim, B. Xu, and L. Cai, “Modular soft stretchable low-cost elastomers for stereolithography printing structures with extreme dissipative properties.”
- [7] A. Saxena, “Novel self-strengthening metamaterials via additive manufacturing - ProQuest.”

Award Request And Budget Justification

A. Award Request

The proposal team requests a total award of \$79,598.25 for the acquisition of the DIC system and a PC for post-processing of DIC data. Official quotes for each item are attached to the proposal. If the proposal is awarded, multiple competing quotes will be acquired before purchasing.

B. Budget Justification

DIC System

An amount of \$70,598.25 is requested for the StrainMaster 3D-DIC System by LaVision Inc. The system includes the following features:

1. Two DIC cameras
2. Illumination and mounting setup
3. DIC timing computer and electronics: This PC is integrated with the mechanical testing machine to time the start and stop point for each test.
4. Software: Lifetime licenses of the timing software and post-processing software are included in the price. A total of two licenses are included.
5. Speckle pattern kit: Used to create speckle patterns on test coupons.
6. Installation and 2-day training is also included in the price.

Please refer to the attached quote for itemized costs.

2. Post-Processing PC

An amount of \$9000 is requested for the purchase of a high-performance PC that will be used to process DIC images. DIC systems can acquire thousands of images (depending on the test) and require large amount of storage and processing power. This PC will be used exclusively for processing of DIC images. The requested PC includes the following features:

1. Processor: AMD Ryzen™ Threadripper™ PRO 7975WX (128MB total cache 32 core 64 thread 4.00-5.30GHz Turbo 350W)
2. Graphics card: NVIDIA® RTX™ 4000 Ada Generation, 20 GB GDDR6, 4 DP
3. RAM: 128 GB: 4 x 32 GB, DDR5, 5200 MT/s, RDIMM, ECC
4. Storage: 4TB SSD
5. Chassis: DellPrecision 7875 Tower 1000W Chassis (DAO 2SATA Flexbay) with liquid cooling for the processor



Quotation prepared for:

Ankit Saxena
 University of Wyoming
 asaxena@uwyo.edu
 814-232-8559

Quote Date: **November 27, 2024**

Customer Ref:

Payment Terms: Net 30 days from date of delivery

Quote Validity: 90 days

Warranty: 12 months after delivery

Estimated Delivery: 16 weeks ARO

Note: Send all POs by EMAIL or U.S. Mail

StrainMaster 3D-DIC System

Item	Qty	Article	Model Description	Unit Price	Amount
Camera					
1a	2	1101761	Imager US-5 Camera - 2440x 2040 pixels, 72 frames/sec at full resolution, 2.7 x 2.7 micron pixels, 8 or 12 bit digital output, 70% maximum QE @ 510 nm, very low 2 e read-out noise, USB Interface (5 m cable)	7,440	14,880
2	2	1013994	Camera Lens - f=35 mm, min. F# 2.0, filter M37.5, MOD = 0.2 m, 1.1"	630	1,260
3	2	1108563	Camera Lens Filter - fluorescence imaging filter 570nm LP M52	1,200	2,400
Illumination					
4	1	1103521	LED illumination set 2x LED35 units with 3 x 3 LEDs colour: blue for triggered flash and CW illumination, with overpulsed function, can be controlled from DaVis software requires Device Control Unit (DCU 11) (#1104340/41 or 1104342/43)	3,840	3,840
Mounting					
5	1	1103318	3-D Portable StrainMaster System Mount - heavy duty tri-pod, 1 m optical rail, 2 x camera gear head with slider mount, 2 x LED gear head with slider mount, room for DCU-X	4,080	4,080
6	1	1103325	VZ-mech extension 1000mm, Strain portable	1,030	1,030
PC & Electronics					
7	1	1104401	Device Control Unit 11 - synchronization unit for control of all hardware components, built-in Windows compatible PC operating system English compact housing, mouse and monitor sold separately.	7,680	7,680
8	1	1104407	Control set for DCU 11 - Monitor, mouse, keyboard (english)	680	680
9	1	1107320	A/D Converter (ADC-250-PCIe) - for external signals, 16-bit dynamic range, 250 kHz sampling rate, 8 channels (differential), integrated into DaVis software	3,360	3,360

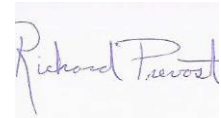
Software

10	1	1105420	<p>DaVis 11 Software license - for image acquisition and processing for Windows 11 Lifetime license: free support through email and phone; can be installed on any number of computers (Floating License) Integrated solution: full control of all hardware components Modular platform concept: expandable with application specific software packages (multi-parameter imaging) project-oriented data management, structured data storage (traceability) Context-sensitive guided workflow: calibration, recording, processing, display and export in one software processing toolbox with integrated filters, image processing routines, hyperloop functionality Access to free DaVis tools: cross-link software plug-in for Matlab for reading and writing DaVis files and for Tecplot for 3D display, IRO control app Software features: Stream-format for efficient storage of long image sequences and fast download from High-Speed cameras, integrated display of 3D data, Tomo-PIV, 4D data from STB; user-specific display options (Zoom, Overlays, false color etc.); individual workspace configuration graphical hardware device manager for easy hardware setup and intuitive cabling Interactive live view: Change of parameters during recording, live processing allows instant feedback Macro programming language (CL): for flexible programming of individual data processing routines Import and export of common image formats (BMP, PNG, JPG, TIF), movies, data files (Tecplot, Matlab), raw formats; Integrated AVI Movie Generator; synchronized side-by-side movies of multiple data set in the same movie Calibration: comfortable software dialogues for scaling, dewarping and calibration of multi camera systems Comprehensive scanning control of time and space scans for automatic acquisition of 4D data arrays Software dialog tools, e.g. for x/y-plots, overlay of meta data, dynamic range and focus quality</p>	6,000	6,000
11	1	1105021	<p>2D Deformation/Strain Software package - cross-correlation image processing algorithms (least squares matching - LSM) with high accuracy and spatial resolution, multi-pass correlation with gradient-defined cell deformation, automatic adaptive cell size/orientation for precise deformation gradient resolution, advanced displacement field post-processing, and comprehensive image and deformation/strain computation and display.</p>	3,960	3,960
12	1	1105022	<p>3D Deformation/Strain Software package - cross-correlation image processing algorithms (least squares matching - LSM) with volumetric reconstruction of 3-D surfaces, full representation of 3-D deformation and strain fields and 3-D surface structure</p>	7,800	7,800
13	1	1105421	<p>DaVis 11 Software license (Processing only) - for data processing for Windows 11 Lifetime license: free support through email and phone; can be installed on any number of computers (Floating License) Modular platform concept: expandable with application specific software packages (multi-parameter imaging)</p>	3,600	3,600
14	1	1105121	<p>2D Deformation/Strain Software package (Additional License) - cross-correlation image processing algorithms (least squares matching - LSM) with high accuracy and spatial resolution, multi-pass correlation with gradient-defined cell deformation, automatic adaptive cell size/orientation for precise deformation gradient resolution, advanced displacement field post-processing, and comprehensive image and deformation/strain computation and display.</p>	1,800	1,800
15	1	1105122	<p>3D Deformation/Strain Software package (Additional License) - cross-correlation image processing algorithms (least squares matching - LSM) with volumetric reconstruction of 3-D surfaces, full representation of 3-D deformation and strain fields and 3-D surface structure</p>	3,360	3,360

Quotation

Quote Number: RP-8488-2(UofWy)

		<i>Speckle</i>			
16	1	1103350	Speckle pattern toolkit - includes 1 x handle, 2 x foam roller 1 x sponge, 1 x extra-large ink pad, all stored in a case; paint to be ordered separately depending on the application	250	250
17	1	1012056	Fluorescent Orange paint to apply speckle pattern; bottle with 150 ml	75	75
		<i>Calibration</i>			
18	1	1107201	Set of five single plane calibration plates (fluorescent) for use with blue light; consists of type: 1 x QR1-102-3.5; 102 x 60 mm 1 x QR2-130-4.7; 130 x 80 mm 1 x QR3-169-6.4; 169 x 109 mm 1 x QR4-227-8.5; 227 x 146 mm 1 x QR5-306-11.6; 306 x 197 mm	1,680	1,680
		<i>Installation</i>			
19	1	1102012	System Installation and Training - 2 days on-site by a qualified LaVision representative	5,000	5,000
				Subtotal	72,735.00
				Educational Discount 5.0%	-3,636.75
					0.00
				System Shipment and delivery	<u>1,500.00</u>
				DDP Total US\$	<u><u>70,598.25</u></u>



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 Applications Specialist
 LaVision Inc.
 E-mail: rprevost@lavisoinc.com
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PFSG205	12/10/2024	PFSG205	10718016	\$9,000.00

QUOTE DETAILS

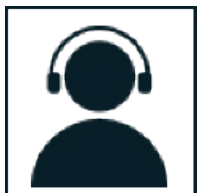
ITEM	QTY	CDW#	UNIT PRICE	EXT. PRICE
DELL CTO 7875 7975WX 4/128 W11P	1	8191081	\$9,000.00	\$9,000.00

Mfg. Part#: 3000183775148

Contract: University of Wyoming MSPSA 29623 (29623)

SUBTOTAL	\$9,000.00
SHIPPING	\$0.00
SALES TAX	\$0.00
GRAND TOTAL	\$9,000.00

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Billing Address: UNIVERSITY OF WYOMING ACCOUNTS PAYABL 1000 EAST UNIVERSITY AVE DEPT 3945 LARAMIE, WY 82071-2000 Phone: (307) 766-1121 Payment Terms: NET 30 Days-Govt/Ed	Shipping Address: UNIV OF WYO - INFO TECH UWIT TECH SALES 16TH AND GIBBON STREETS UW PO: LARAMIE, WY 82071-2000 Shipping Method: DROP SHIP-GROUND
	Please remit payments to: CDW Government 75 Remittance Drive Suite 1515 Chicago, IL 60675-1515



Sales Contact Info

JB Washburn | (877) 669-4340 | jb.washburn@cdwg.com

Precision 7875 Tower

Estimated delivery if
purchased today:

Dec. 17, 2024

Contract #

C000000006679

Description	SKU
Precision 7875 Tower CTO BASE	210-BKJK
AMD Ryzen Threadripper PRO 7975WX (128 MB cache, 32 cores, 64 threads, 4.0GHz to 5.3GHz, 350 W)	338-CMWB
Windows 11 Pro, English, Spanish, French, Brazilian Portuguese	619-ARSE
Performance Heatsink - Air Cooling	412-BBHT
128 GB: 4 x 32 GB, DDR5, 5200 MT/s, RDIMM, ECC	370-BCLT
Nvidia RTX 4000 Ada, 20 GB GDDR6, 4 DP	490-BKGW
SATA Upper/Lower Flexbay Assembly included with chassis	340-DCMT
M.2 NVME Boot Drive	340-DCMU
Integrated Storage Controller	403-BCVC
No Hard Drive	400-AKZR
No Hard Drive	400-AKZR
No Hard Drive	400-AKZR
No Hard Drive	400-AKZR
E0: No Expansion Bay	429-ABMS
CMS Software not included	632-BBBJ
4 TB, M.2, PCIe NVMe, SSD, Class 40	345-BJGF
No Hard Drive	400-AKZR
No SATA/SAS RAID	780-BBCJ
No M.2 NVME RAID (C1, C2)	780-BCSY
Precision 7875 Tower 1000W Chassis (DAO 2SATA Flexbay)	321-BKLS
Toolless Bezel Included with Chassis (C1)	325-BFNS

System Power Cord C13 (US 125V, 15A)	470-AATC
No Additional Network Card Selected (Integrated NIC included)	555-BBJO
Keyboard not included	580-AADS
ENERGY STAR Qualified	387-BBLW
EPEAT 2018 Registered (Gold)	379-BDZB
Dell Precision TPM SERI Guide (ENG/FR/Multi)	340-ACBY 340-AGIK
Quick Start Guide placemat, Precision 7875	340-DMDH
Shipping Material (DAO)	340-CBUU
MOD,SHP MTL,PWS,TRAMORE,DA O	340-DMDJ
Precision 7875 1000W Regulatory Label	389-FFTW
No External ODD	429-ABGY
Resource DVD not Included	430-XXYU
Dell Additional Software	658-BFPP
Dell PremierColor 6.2	640-BBST
Dell Limited Hardware Warranty Plus Service	997-5852
Onsite/In-Home Service After Remote Diagnosis 3 Years	997-5854