HIGHER EDUCATION COMMISSION
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Proposal
Identification Number

National Research Program for Universities
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Title of Proposed Project:----- INTEGRATED PEST MANAGMENT USING MULTISPECTRAL MACHINE VISION

Nature of Proposed Research:	Basic ☐ Applied ■ Community ☐ Commercialized ☐ Thematic ☐
Domain of Proposed Research:	Arts and Humanities ☐ Economic & Social Research ☐ Engineering & Physical Sciences ■ Medical sciences ☐ Biotechnology & Biological Sciences ☐ Natural & Environment sciences ☐ Science and Technology
Subject (e.g. Chemistry):	Machine Vision
Major field (e.g. Organic Chemistry):	Electronics Engineering
Minor Field (e.g. drug):	Active Vision
Specialization (Nano techniques):	Robotics
Turnitin similarity index (%):	0
Details of Principal Investigator (PI):	**Dr Muhammad Wasif**
Name of the PI:	**Dr Muhammad Wasif**
Is PI appointed on BPS or TTS: If appointed on Contract:	BPS
Contract period:	N/A
Remaining period of the contract(RMC):	N/A
Proposed Starting Date of Project:	1st January 2018 / Just after approval
Designation of PI (Asst. Prof./Ass Prof./Prof./other):	**Assistant Professor**
Grade/equivalent grade of the PI (BPS 17/18/19/20/21/22):	19
Proposed Duration of Project (in months) :	36 months

Department:	Electrical Engineering
Name of the University:	University of Gujrat
Is University Public or Private:	Public
If Private university (is it eligible for public funding):	N/A
University Campus/sub Campus:	Hafiz Hayat Campus
Province of the University:	Punjab
CNIC# of PI:	34201-0471843-7
Email address:	syed.wasif@uog.edu.pk
Cell and Phone # :	03216206309
Total Funds Requested (in million):	5.53 Millions
Impact factor:	3.00
NRPU projects with their ID No:	**N/A**
a. Completed:	**N/A**
Give Project ID Nos of completed project:	N/A
b. Ongoing:	**N/A**
Give Project ID Nos of ongoing project:	**N/A**
c. Under review process	**N/A**
Give Project ID Nos of under review project:	**N/A**
Mentioned beneficiary industry: **(Letter of support for industry problem to be attached)**	Ayub Agricultural Research Institute, Entomological Research Institute

COVER SHEET FOR PROPOSAL

A. **Title of Proposed Project**

INTEGRATED PEST MANAGMENT USING MULTISPECTRAL MACHINE VISION

B. **Nature of Proposed Research**

B1. Basic ☐ B2. Applied ■ B3. Community ☐ B4. Commercialized ☐ B5. Thematic ☐

C. **Domain of Proposed Research**

C1. Arts & Humanities ☐ C2. Economic & Social Research ☐ C3. Engineering & Physical Sciences ■
C4. Medical sciences ☐ C5. Biotechnology & Biological Sciences ☐ C6. Natural & Environment Sciences ☐ C7. Science and Technology ☐

D. **Field of Proposed Research and Specialization** [For example;
(**Subject**: Agriculture; **Major Field**: Soil Science; **Minor Field: Macro-nutrient; Specialization**: Modeling)]

D1. **Subject:** Machine Vision

D2**. Major Field**: Electronics Engineering

D3. **Minor Field:** Active Vision
D4**: Specialization**: Robotics

E. **Project Digest** (Describe the proposed research geared to the non-specialist reader)

Pakistan is an agricultural country generating almost 60 percent of GDP from textile exports. The third most important crop or principal industrial crop in Pakistan is cotton form which most of the export revenues are generated. In world, Pakistan is the fourth largest cotton lint and first largest cotton yarn producer. With increasing demand of cotton against disproportional growth of cotton crop put Pakistan's agricultural economy on risk. A report titled with "Pakistan's cotton emergency", published in MIT technology review for year 2015-16, highlighted that 28% decline in cotton shows calamitous agricultural economical revenues. The production of cotton was mainly reduced due to ineffective control of pests against their attacks. With every year increase of pesticides' demand and extensive use of pesticide chemicals for pests control concerned the farmer community because of its side effects *i.e.,* non-optimal spray of pesticides involving wastage of capital, inflated pests/bioaggressors resistance against pesticides, killing of crop supportive pests, and pollution etc. Since the contemporary pests' control mechanisms rely on outright spray of pesticides to kill harmful insects without involving the information of cost, crop friendly pests, and environment. This raises a demand of an integrated approach for pest detection, identification and specific pesticide spray in only affected area or some other non-chemical measures to destroy pests/bioaggressors. This integrated pest management (IPM) approach can optimize the usage of pesticides with proportional reduction in cost and environment pollution. The objective of this integrated pest management scheme is to utilize the state-of-art technology for early pest detection and identification. This early pest management will enable a farmer to identify the insect pest and localize its affected area for particular pesticide spray or some other useful action.

E1. Quantifiable measure of impact on society after project completion.

- The objective of the project is to provide an integrated pest management system for agricultural sector to control the bioaggressors' attack on a crop in an optimal way while pertaining minimum cost of pesticides and less damage to environment and supportive bio-organisms.
- Employing the proposed integrated pest management system with early pest detection will enable the farmers to execute in time an appropriate control action with less laborious effort while incurring less cost and minimum crop damage within lower limit of economic loss.
- The proposed integrated pest management system will provide a framework, employing which will improve the agricultural revenues of Pakistan with proportional increase in export of agricultural products.

E2. Proposed Duration of Project: (in months)	E3. Proposed Starting Date	E4. Total Funds Requested
24 months	1st January 2018 / Just after approval	5.53 (in million)

F. **Details of Principal Investigator (PI)**

F1. Full Name of PI (First-Middle-Last)	F 2. Highest Degree	F 3. Position/Title (BPS/TTS)
Dr Muhammad Wasif	**PhD**	**BPS**

F 4. Department/Section	F 5. University/Institution	F 6. CNIC / Passport:
Department of Electrical Engineering	University of Gujrat	34201-0471843-7

F 7. Mailing Information

a. Mailing Address:	b. Email:	c. Telephone: (Area code, number and extension)
Room# E-204, Engineering Block, Hafiz Hayat Campus, University of Gujrat	syed.wasif@uog.edu.pk	Office : 0533643331 Mobile: 03216206309 Res: 0533707165

G. **Details of Co-PI**

G1. Full Name of Co-PI (First-Middle-Last)	G2. Highest Degree	G3. Position/Title (BPS/TTS)
Dr Sajjad Miran	PhD	TTS

G4. Department/Section	G5. University/Institution	G6. CNIC / Passport:
Department of Mechanical Engineering	University of Gujrat	034603-2164186-9

G7. Mailing Information

a. Mailing Address:	b. Email:	c. Telephone: (Area code, number and extension)
Room# E-204, Engineering Block, Hafiz Hayat Campus, University of Gujrat	sajjad.miran@uog.edu.pk	Office : 0533643331 Mobile: 03314957621 Res:

H. Declaration/Certificate:

It is hereby certified that:

a) PI is a full time regular faculty member (BPS or TTS) or is hired on contact not less than project life.

b) Equipment(s) demanded for the subject project is / are not available in the University / Institute.

c) No portion of this project has been submitted and /or funded by HEC or any other funding agency.

d) Subject project is genuinely novel and that there is no plagiarized material including self-plagiarism.

e) PI has never been blacklisted by HEC.

f) PI is neither currently executing two projects (ongoing) nor has submitted/ already submitted two projects simultaneously under any of HEC grants program, e.g. NRPU or UITSP or TDF or TRGP or Pak-US etc.

a) PI is not executing any NRPU project whose completion is delayed by three (03) years

b) Host University/DAI will provide complete support for the establishment & operation of this project, if funded by HEC, and also provide other facilities including land, building, space, laboratories, machinery, equipment, transport, amenities including utilities and other services throughout the life cycle of this project.

Signature of Principal Investigator

Signature with Stamp of Director (ORIC)/Research Office/Registrar Office

Signature with Stamp of the Head of Institution
(Vice-chancellor/Rector of University/
Director of Degree Awarding Institution)

PROJECT DETAILS

Project Summary (Describe the proposed research)

- The objective of this project is to design and implement an integrated pest management system equipped with an intelligent machine vision system mounted on a teleoperated or autonomous quad-copter.
- The proposed system will be used to perform multi-spectral pest scouting in visible, infrared, near-infrared, and ultra-violet frequency bands. This multi-spectral machine vision system will be used to attain early pest detection and identification.
- An autoencoder neural network model, trained and tested with real-time multi-spectral pests' images, will used to identify and classify the detected pests.
- Using the proposed system the information of pest population size will be extracted from the captured images after observing the pests' density in a unit area.
- Furthermore the location of pests' affected area will be localized using GPS information.
- This early pest identification, detection, and localization will provide useful information for a specific pesticide spray on a specific affected area or some other non-chemical action (*e.g.,* destroying affected plants) can be executed, instead of whole range pesticides' spray in the whole field.
- Using this integrated pest management system, an optimized quantity of particular pesticide spray on a localized area will result proportional reduction in pesticide's cost and environment population.

2. Proposed Goals/Objectives (Please identify quantifiable goals)

- If the proposed research is basic, please identify or postulate scientific hypothesis on which your proposed goal is based.
- If the proposed research is applied, please identify the output in the form of a product or process, need or relationship to industry and also identify the end-user of your output/ product.
- Principal investigator is encouraged to make preliminary inquiries with the proposed end user and attach any certificate/ document in support of the proposed research.

2A. Hypothesis/Basis of Research (If research is basic)

2B. Goals/Objectives (Please quantify your objectives. Moreover, describe how proposed research is relevant to national needs)

- Design and implement a multi-spectral pest detection, identification, and classification algorithm that can also be used to determine the population size and localization of particular pest.
- Mount an airborne multi-spectral system on a teleoperated or autonomous quad-copter.
- Collect the real-time multi-spectral insect pests' images for the online training of proposed autoencoder neural network.
- These captured images will also be registered to build an insect pests image database for later theoretical validation of the proposed neural network model and for off-line reliability determination at first.
- The trained network will be thoroughly tested on-line using real-time multi-spectral images with a large number of quad-copter flights, in addition on-line reliability of the system will also be quantified.

2C. Identify end user/ beneficiary industry. (Support letter to be attached)

The proposed integrated pest management system capable to perform automatic early pest scouting which will provide farmers a cost effective and non-laborious solution. Furthermore, the bioaggressors' detection, identification, and classification enables the farmers to spray specific pesticide instead of broad spectrum pesticide's spray or take some other controlling measure. A supporting letter is attached herewith the proposal to signify the beneficent end-user. The director of entomological research institute is also a Co-PI in the proposed project (the CV of Co-PI is also attached herewith the proposal).

3. **Introduction** (The introduction should consist of three paragraphs; the first paragraph indicating the scientific hypothesis/commercial basis on which the project is based, the second introducing the precise nature of the project, while the final paragraph highlighting the proposed objectives in the light of the first two paragraphs).

The agricultural revenues of Pakistan are on declination due to inefficient and infantile agricultural system against bioaggressors control and crop damage protection. An integrated pest management system is required to adopt appropriate measures in order to control the attacks of pests and to limit the crop damage within a bearable economic limit. Early pest management with early pest detection, identification, and classification will enable the farmers to in time control the bioaggressors' damage before a major crop damage and consequent economic loss. If an intelligent multi-spectral machine vision system is used, installed on a teleoperated quad-copter, it will allow to perform efficient and non-laborious pest scouting in day and night for early pest detection & identification. The multi-spectral imaging of crop field will provide improved visual features *e.g.*, improved contrast between the pests and leaves, which otherwise are not available in the visible range images. Employing an integrated pest management supported with multi-spectral pest imaging will enable early pest control and will reduce the crop damage using optimized pesticide's spray.

The proposed integrated pest management system is applied in nature and based on multi-spectral machine vision techniques. This system will provide an integrated pest management system using which pests can be identified at early stage so as to take appropriate measures for pest control. The proposed system will be a major breakthrough for Pakistan's agricultural industry in order to increase its production in parallel to the rising demands of agricultural products.

The proposed system will be developed using an airborne multi-spectral imaging system mounted on an areal teleoperated vehicle. Using the proposed system airborne pest scouting will be performed in day and night for early pest detection in order to execute appropriate insect pests' control measures.

4. **Justification for the research problem** (Not more than two pages**)**
   - **In case of basic research**, a comprehensive and up-to-date literature survey clearly highlighting the existing gaps and what new information will be added to the existing pool of knowledge.
   - **In case of applied research**, identify the industry in Pakistan which will get benefit from the process/ product.
   - Justify how the proposed research will contribute to the national economy/social sector.
   - The principal Investigator is encouraged to discuss the proposed research with the proposed beneficiary and attach supporting documentation.

In the modern age, the angle of inclination in capital flow towards a country is a cue of development of its economy and improvement in national employment and resulting in a better life standards of a nation. The agricultural products add major revenue in the export economy of Pakistan. The cotton is an important crop generating the most of Pakistan's export revenues. However, there was a drastic decline during last couple of years in cotton products due to an inefficient control of the bioaggressors' attacks, mainly because of manual pest scouting or other sampling methods *e.g.,* sticky trap. Since human-based pest scouting requires manual field surveys and is very imprecise, inaccurate sampling, laborious, time consuming, and cost devouring activity (López, Otoniel, et al. 2012). There is an immense need for better pest scouting mechanism capable to detect and classify a broad spectrum of bioaggressors/pests at the earlier stages of their growth and outspread. At this time there is no an off-the-shelf available solution that can be utilized for the said task. This raises a demand for an automatic, inexpensive, fast, accurate, and efficient integrated pest management system capable to perform bioaggressors pest scouting in large field areas. The integrated pest management concerns with an optimized management strategy handling pests in an economically efficient and pollution free manner (Stern et al., 1959; Solis-Sánchez, L. O., et al., 2009; Koumpouros et al. 2004). In agricultural domain the continuous monitoring and control of the insect bioaggressors/pests is a key issue of the modern time.

The objective of this research project is to design, develop and implement an automatic, precise, and efficient pest scouting system capable to perform pest scouting in day and night using an airborne multi-spectral imaging system mounted on a quad-copter. The proposed integrated pest management (IPM) system will be able to counter for the substantial existing problems including efficient insect pests control, suboptimal pesticides'

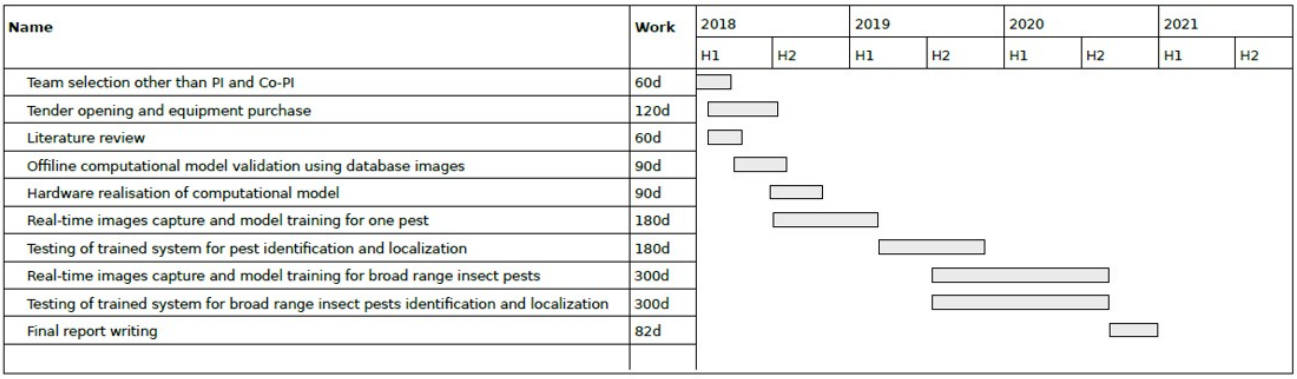
spray, inability to detect the full range bioaggressors/pests, and the environment pollution. The proposed system will be used for early pest detection and presence of pests or disease symptoms with aim to control the pests attack within a smaller area before the outspread to full cotton field. Consequently, a specific type of pesticide will be sprayed based on the detected pests in smaller affected area followed with a considerable decrease in pesticides' cost.

4A. Research plan/ Methodology (Schedule/Phasing)

The proposed system will be based on a multi-spectral imaging system capable to capture real-time multi-spectral images in visible, infrared, near-infrared, and in ultra-violet frequency bands similar as used in various studies for in situ pests detection in a controlled farm house or in laboratory based experiments (Al-doski Jwan, et al., 2016; Cao Peng-fei, et al., 2013; Boissard Paul et al., 2008; Yang Chenghai, et al., 2014; Feng Jie, et al., 2009; Feng Jie, et al., 2009; Liu Huajian, et al., 2017; 25. Yang Chenghai, et al., 2014). The multi-spectral images will be used to determine the saliency information in each frequency band then these spectral salient images will be fused to produce multi-spectral salient image retaining improved required image features of the insect pests. The features of pests will be extracted using shape, dimension, orientation, motion, depth and colour filters which will be combined to produce a saliency map. This saliency map will be used to provide inputs to the PC/BC-DIM autoencoder neural network model proposed in (Muhammad Wasif, and Michael W. Spratling, 2017a, 2017b. 2015) for pest detection, identification and classification task. The same network model was used in (Spratling, 2017c) for object recognition in natural images. The proposed autoencoder model will be on-line trained using real-time multi-spectral images captured from the cotton fields of Entomological research institute, Ayub agricultural research institute, during the network training surveys of the teleoperated quad-copter. During each flight the acquired images will also be registered for off-line theoretical studies of the propose neural network model. After full training, the real-time testing of the proposed system will be done in real-time cotton fields.

Project Gantt Chart is attached

Project Gantt Chart



WBS	Name	Start	Finish	Work	Duration	Slack	Cost	Assigned to
1	Team selection other than PI and Co-PI	Jan 1	Mar 23	60d	60d	722d	0	
2	Tender opening and equipment purchase	Jan 29	Jul 13	120d	120d	642d	0	
3	Literature review	Jan 29	Apr 20	60d	60d	702d	0	
4	Offiline computational model validation using database images	Apr 2	Aug 3	90d	90d	627d	0	
5	Hardware realisation of computational model	Jun 25	Oct 26	90d	90d	567d	0	
6	Real-time images capture and model training for one pest	Jul 2	Mar 8	180d	180d	472d	0	
7	Testing of trained system for pest identification and localization	Mar 11	Nov 15	180d	180d	292d	0	
8	Real-time images capture and model training for broad range insect pests	Jul 15	Sep 4	300d	300d	82d	0	
9	Testing of trained system for broad range insect pests identification and localization	Jul 15	Sep 4	300d	300d	82d	0	
10	Final report writing	Sep 7	Dec 29	82d	82d		0	

4B. REFERENCES

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5. **Impact in Quantifiable Terms** (Impact of proposed research on teaching/training of manpower, institutional capacity building and on local industry; on economic development of national, regional and community development).

The completion of the proposed project will put following quantitative impact on society:

1. The educational outcome of this project will be start of a machine vision research group involving faculty and students focused on solving the current problems of Pakistan especially faced in agricultural sector *e.g.,* pest control, weed control *etc*.
2. Foremost advantage of the project is a deliverable solution for the national agricultural industry to increase its agricultural throughput. In turn formers will get better economic returns of their agricultural products.
3. The increase in better quality agricultural products will provide Pakistan self-sufficient power to meet its national and international demands of products along with inclination in the agricultural export revenues.

6. **Sustainable Development Goals (SDG's)** (How and which of the SDG's will be addressed in this study? Justify how the proposed research will contribute to achieve SDG's of Pakistan. For details on SDG's /s please visit:)
http://undocs.org/A/68/970
http://www.un.org/sustainabledevelopment/sustainable-development-goals
http://www.slideshare.net/derekschwabe/the-17-proposed-sustainable-development-goals

1. Sustainable economic growth (SGD#8): The main objective of the proposed research is to cure the damaging agricultural export revenues due to inefficient pest detection and control system. The outcome of this project will support the agriculture sector to overcome the existing problems which put the agricultural economical revenues in a calamitous phase.
2. Resilient and reliable industrial infrastructure (SGD#9): The proposed project will provide a reliable and flexible solution for integrated pest management by employing the modern technological solutions for the agricultural infantile industry.
3. Fixed average production of the agricultural products (SGD#12): With the support of the proposed solution the agricultural industry can uphold the agricultural production to an average level or above that level.

7. **Collaborating organizations** (PI's are encouraged to collaborate with partner(s) within Pakistan, preferably from under developed areas. While collaborating with research group (national / international or local industry):

- Identify complementarity and/or justify the need for collaboration.
- Clearly identify the part/s of research that will be carried out in the participating laboratory.
- Include a letter from collaborating partner/agency expressing willingness to collaborate.
- Mention cost sharing by collaborating institution/s.

The proposed project will be conducted in collaboration with the **Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad**. The entomological research institute is already working on the identification of insect pests damaging the crops with manual pest screening/scouting, standardization of pesticides, and improvement in pest control techniques. This collaboration in the proposed project will provide ability provide solution of real problems being faced using the automatic pest scouting in the cotton fields using the proposed system. The computational model used in the proposed system will be trained and tested in the cotton fields of the collaborated agricultural research institute. The director entomology of the entomological research institute will also act as a Co-PI and will provide useful information and help for defining the appropriate time, growth stages and the seasons for the pest scouting, pest types, growth rate, and its trend *etc*.

8. Facilities and funding

8A. Facilities (Equipment available for the research project in the host university/institution)

i) Two high-speed workstations for computational model development and testing.

8B. Facilities (Equipment not available for the research project in the host university/institution)

i) Multi-spectral imaging system
ii) Teleoperated quad-copter.
iii) Full spectrum light source.

8C. Scientific Personnel

i) Available?
PI and Co-PI and collaborated industrial Co-PI available for the smooth conduction of the proposed project. Currently four MSc students working under the supervision of PI on other machine vision and control projects.
ii) Required? (Engaging research students is encouraged)
One MSc student as research assistant in each year is required for execution of the project.

8D. Other funding available for the proposed studies (if any)

N/A

9. Principal Investigator (In addition to the following information, also provide one-page summary of each research project completed, on-going or submitted (to HEC or any other funding agency) as PI or Co-PI.)

Sr. #	Title of Project	Initiation date	Completion date	Amount(s) awarded	Funding source(s)
1	***Hybrid Bottom-up and Top-down Stereo Visual Saliency Detection***	**12-04-2017**	**12-04-2018**	**0.475 Million**	**Higher Education**

	Model				**Commision Project #SRGP-1332**

To initiate action in an appropriate motor space requires mapping and interaction of salient visual information from a sensory modality to this motor space. However, the natural environments are very complex and cluttered with redundant visual information. Therefore it is non-trivial to select salient visual information while suppressing the remaining non-salient information. The salient information can be transferred in a bottom-up direction based on the visual features of a scene and can be selected in a top-down manner from multiple bottom-up transferred salient instances. Similar hybrid bottom-up and top-down saliency detection mechanism functions together in the human central nervous system (CNS). In previos work, Muhammad and Spratling (2015), Muhammad and Spratling (2017a) and Muhammad and Spratling (2017b) used a very impoverished visual environment with blank background for sensory-motor coordination. The research of this project will overcome this limitation and provide ability in previously developed framework to perform sensory-motor transformations in a realistic and natural environment.

The objectives of this research are:

I. A neural computational model will be developed employing mutual coordination for stereo saliency detection.
II. An interactive hybrid bottom-up and top-down saliency detection and selection mechanism will function together. The saliency selection will be made between saliency information based on a desire, initiated from top-level, to foveate to a target or from different sensory modalities in the head-centered coordinates.
III. A coordinated eye-head gaze shift along with binocular vergence will be performed to foveate to a desired location in the visual scene after visual saliency selection.

A pair of saliency maps will be developed for stereo vision sensory-motor transformations and motor actions. Each saliency map will be based on a PC/BC-DIM basis function neural model similar as proposed in previous work (Muhammad and Spratling; 2015, 2017a, 2017b). Each saliency map will fuse information emerging from separate feature maps. The mutual interaction between both saliency maps will be used to coordinate to represent same salient object in both eyes. This mutual interaction between saliency maps can be based on the target symmetry and stereo disparity to compare whether the same information is salient in both eyes. In case of simultaneously appearing multiple salient targets in a visual scene, the visual information will be transformed to represent in head-centered coordinates where top-down saliency selection mechanism will decide to select one salient information based on the interest level to converge to one object. Similar bottom-up and top-down interactions can be used to select saliency presented by different sensory modalities.

9A. A Brief Resume of PI (PERSONAL INFORMATION, Education and experience, Title of Thesis (MS/ PhD), Teaching expertise, **PROFESSIONAL MEMBERSHIPS,** List of Publications, Books Published, Research skills, other relevant facts, references, etc.)

(Please attach CV of PI and Co-PI)

Attached

10. Estimated budget for the proposed research period: PLEASE NOTE THAT AS PER NRPU POLICY:

a) No foreign payment could be made either to any firm for the purchase of any item or to any foreigner Co-PI.
b) International travel is not allowed. However, PI may go abroad if he/she is funding/supported by a collaborating partner.
c) However, travel expenditure as per actual can be claimed under head local travel but maximum up to 0.2 million per year.
d) Food/entertainment expenditure can not be demanded in the budget.
e) The only studentship is allowed (M. Phil./MS/MSc(Hons)/PhD students)
f) No research associate/research assistant/field assistant/field surveyor/ or any supporting staff etc. can be engaged other than studentship in the project.
g) However daily paid labor (DPL) can be demanded for a specific time period and may be hired at university rates if justified under the proposal.
h) Secretariat Staff (if required & justified by PI) is allowed @ Rs=18,000 per year.
i) No coordinator/consultant is allowed to be hired as it is the responsibility of PI/Co-PI.
j) Total amount of the project would never be exceeded 20 million in any case if PI,s impact factor allowed.
k) If permanent equipment/s are already available in the host university/institute or their contribution in the execution of the project is not significant, please cut them down.
l) If year wise quantity and cost of expandable supplies demanded is not justified either these are not required or overestimated? Please cut them down to a reasonable size.

Description	% of time devoted to project	year 1	year 2	year 3	Amount (in million Rs.)
A. Salaries and Honorarium					
PI: (Either on BPS or TTS) One month initial basic pay of scale per year on following rates: Assistant Professor: Rs=59210/-	**30**%	59210	59210	59210	0.17763
Co-PI: (Either on BPS or TTS) One month initial basic pay of scale once in entire project life on following rates: Assistant Professor: Rs=59210/- Professor: Rs=76720/-	**10**%+**5**%	-	-	59210+76720	0.05921+0.07672= 0.13593
Studentships @					
Rs=25000/- per month for Ph.D.					
Rs=20000/- per month for M.S./M.Phil.	**100**%	240000	240000	240000	0.72
Subtotal:					**1.03356**

B. Permanent Equipment (Please attach invoice/quotation and expected delivery date for items costing Rs. 0.1 million or above)					
Macaw (MCAW)-Tetracam's Multiple Camera Array Wireless System					2.3
Quad Copter matrice 600					0.768
Full spectrum light source					0.015

Mobile workstation					0.41
Subtotal:					**3.493**

C. Expendable Supplies (It is mandatory to give year wise quantity and cost with full justification)					
Expendable/Consumable Accessories					0.27962
Subtotal:					**0.27962**

D. Local Travel (Purpose of local travel, with justification and detailed calculations of each visit/ tentative schedule of visits for each year on a separate sheet)

- Please note that:
  - m) TA/DA is not allowed under NRPU, however, estimated expenditure as per original may be demanded
  - n) However, travel expenditure as per actual can be claimed under head local travel but maximum up to 0.2 million per year.
  - o) International travel is not allowed. However, PI may go abroad if he/she is funding/supported by a collaborating partner.

Local Travel (Maximum 0.2 million per year or as per actual)					
Local Travel to collect real-time mutli-spectral images and testing		0.04464	0.17856	0.17856	0.40176
Subtotal:					**0.40176**

E. Others (Literature, documentation, information, online literature search, contingencies, postage, etc.)					
Journal publication fee / Online material (Max Rs=50,000/- or as per actual)		-	-	-	0.05
Stationary/Contingency (Max Rs=10,000/year or as per actual)		0.01	0.01	0.01	0.03
Subtotal:					**0.08**

F. Miscellaneous					
Audit / Accountant Fee (Max. Rs 10,000)					
Audit and tender opening charges					0.01
Subtotal:					**0.01**

Subtotal (D + E + F):					**0.49176**

G. Indirect cost (University overheads)					
15% of total direct cost to meet office support and utilities etc. of ORIC (If ORIC office is fully functional). OR					0.794691
02% of total direct cost to meet research office support and utilities, etc. (if ORIC is not established).					
Subtotal:					**0.794691**
Grand Total (A + B + C + D + E + F+ G):					**6.092631**

11. Justification

A. **Salaries & Allowances** (Please provide justification for studentship)

One MSc student in each project year will be selected for the frequent cotton fields' survey with the proposed system to capture the real-time multi-spectral pests images. The proposed system will also be trained and tested with the help of these scholars. Whereas the PI and one Co-PI will draw the salaries/honorarium as proposed in the HEC project policy against the effort and time each will consume in the proposed project.

B. **Permanent Equipment** (Please identify and justify major items costing over 0.1 million)

Macaw (MCAW)-Tetracam's Multiple Camera Array Wireless System: To capture multi-spectral images of the pests damaging the cotton crop.

Quad Copter matrice 600: For airborne pest scouting using multi-spectral imaging system.

Full spectrum light source: For pest scouting when it is cloudy and there is poor sunshine or for pest scouting in night during maximum pest activities damaging the cotton crop.

Mobile workstation: For on fields multi-spectral images storage and for the off-line validation of the proposed system during the travel periods.

C. **Expendable supplies** (Justification and details of cost and quantity required)

The expandable/consumable components are spare parts *i.e.*, propeller kits, spare battery, power distribution board, electronic speed controller (ESC) , arm kit, screw kit, and arm angle calibrator of the Quad Copter matrice 600. These accessories are required since during the system training phase very large number of flights will be made, hence there is a probability of parts breakdown, damage or failure which will otherwise cause a complete shut down of the proposed system. To complete the project during the set time period it is very important to have these spare parts so as function seamlessly.

D. **Other Costs.** (Justification for travel cost – not exceeding 2 lac per year)

THE OBJECTIVE OF THESE LOCAL TRAVELS IS TO TRAIN AND ON-LINE TESTING THE PROPOSED SYSTEM USING THE REAL-TIME MULTI-SPECTRAL PEST IMAGES ACQUIRED FROM THE COTTON FIELDS OF COLLABORATED ORGANIZATION AND TO SAVE THESE IMAGES IN A DATABASE FOR THE OFF-LINE MODEL VALIDATION.

12. Miscellaneous Information or Questions

Miscellaneous Information or Questions	Yes or No / #
A. Whether HEC approved supervisors as per HEC rules are available in the institute of PI or not?	**YES**
B. How many research students are already registered with PI?	3
C. How many research associates/students funded by HEC or any other organization, the PI has?	1
D. How many non-funded research scholars are registered with PI?	3
E. The published research articles:	4
F. Number of research articles published as a first author.	4
G. Number of research articles published as a co-author with your own M-Phil/PhD student.	0
H. Number of research articles published as a co-author with other researchers.	0
I. Research Projects	1
J. Number of research projects as PI funded by HEC.	0
K. Number of research projects as PI funded by other agencies.	1
L. Number of research projects as Co-PI funded by HEC	0
M. Number of research projects as Co-PI funded by other agencies.	0

13. Check list/ Have you filled/attached copies of all required documents?

Sr. #	Check list/ required documents	Tick (✔) Yes or No	Reference page No.
1.	Is PI a full-time regular faculty member (BPS or TTS) or on contact not less than project life of any public sector university/DAIs or private sector university/DAIs eligible for public funding (list of 29 private sector universities/DAIs is given below). PI must have an advance academic degree & relevant experience (PhD or M.Phil./MS) and working as academician/researcher but not as administrator?	Yes	
2.	Is PI submitted his/her research proposals online through HEC web portal "http://eportal.hec.gov.pk/hec-portal-web/auth/login.jsf" on or before **18 October, 2017**.	Yes	
3.	Has PI never been black listed by HEC?	Yes	
4.	Is PI not executing any NRPU project whose completion is delayed by three (03) years? (If No, please specify their ID number.)	No	
5.	Is PI not currently executing or has submitted two or more projects simultaneously under any of HEC funded research grant programs either under NRPU or UITSP or TDF or TRGP or Pak-US etc. (either ongoing, submitted, under review, etc).	No	
6.	Is **Turnitin** report of the proposal attached?	Yes	
7.	Is PI attached his appoint letter?	Yes	
8.	Has a clearance certificate from Institutional Bioethics Committee (IBC) of the university/DAI concerned attached (if required)?	No	
9.	Have relevant university authorities affixed signatures with date & stamps on the **Declaration Certificates?** (Section **H** of cover sheet for proposal at page # 3)	Yes	
10.	Has a brief of the impact of research project been attached? (Section-5)	Yes	
11.	Is industry support letter attached? (Section-2C)	Yes	
12.	Has a letter of consent from collaborating partner/agency expressing willingness to collaborate been attached? (Section-7)	? No	
13.	Is one page summary of each project of PI already completed/ running/ submitted to any funding agency been attached? (Section-9)	Yes	
14.	Is equipment demanded for the execution of the subject project not available with the University / DAI? (Section-10B)	Yes	
15.	Have original Invoices / Quotations for permanent equipment costing over Rs.0.1 million or more been attached? (Section-10B)	Yes	
16.	Have year-wise cost and quantities of each expendable item been given (Section-10C)?	Yes	
17.	Has tentative and detailed schedule of local visits (annual plan) with justification and rates been attached (if study involves field survey/field work). Please note that TA/DA is not allowed under NRPU, however, estimated expenditure as per original may be demanded? (Section-10D)	?	

18.	Has head of institution duly endorsed the application (Section-14) of the application form?	Yes	
19.	Is total cost of the research project in line with the financial provisions of the NRPU program (with reference to PI's Impact Factor)?	Yes	
20.	Have you provided project activities on GANTT Chart?	Yes	
21.	Have all fields of research proposal been carefully filled and counter checked by the PI?	Yes	
22.	Is PI submitted one complete set of original hard copy of the proposal duly singed from all relevant authorities of the university along with soft copy of duly filled Application Form 2017 to the Office of Research Innovation and Commercialization (ORIC)/Research Office/Office of the Registrar of respective university to make it available -via surface mail/Special Messenger– along with complete record of all the proposals to Director (R&D), HEC to HEC (NRPU) **on or before 18-10-2017** .	Yes	

14. ENDORSEMENT

SIGNATURE OF PI Date	**Signature of the Director ORIC/Research Office /Registrar Office (with Stamp)** **Date**
SIGNATURE OF CO-PI Date	**Endorsement of the Head of Institution (Vice-chancellor/Rector of University, Director of Degree-awarding Institutions**) Signature & Stamp Name & Title: Address: Phone: E-mail Fax: Date: