Brains Bots Builders

Reconfigurability and Redesign in Human-Robotic Systems

Integrating Education and Research
To optimize how we can accomplish more efficient technologies for critical needs

including Agriculture and Environmental Remediation

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The Problems and Challenges

Increasingly EXTREME(ly) COMPLEX SYSTEMS

Critical Singularity States in Nature, Human-Engineered Systems, and Society

Over-complex bureaucracies in research, development and education

Opportunities for the Present and Future Generations to Excel Creatively
Extremely Complex Systems

Especially:

**Aerospace – aircraft and space vehicles**
- Turbulence
- Engineering and Environment Complexity
- Cooperativity
- Uncertainty

**Automobiles, trucks, high-speed trains, other vehicles**
- Self-driving cars
- Mag-Lev
- High-density traffic management
- Load-balancing

**Financial markets**
- Anomaly/Asymmetry Detectors
- Market Predictors

**Population trends and behaviors**
- Socioeconomics
- Market Futures

**Biomedical instrumentation**
- Cardiovascular
- Robotic Surgery

Requirements:
- § Adaptive Generalized Computation Architectures
- § Bio-inspired De-centralized Synthetic Intelligence
- § High-Demand, High-Need, Critical-Service Platforms
Extremely Complex Problems that require a new kind of technology and “STEM business model”

Directions – Applications – Commercializations - Products

**SPACE**
- Exploration/Colonization
- Asteroid Intervention
- Space-based Power
- Mining/Manufacture

**ENGINEERING**
- Civil Engineering
- Architecture
- Infrastructure
- Transportation

**ENVIRONMENT**
- Chem-Bio-Rad Monitoring
- Coastal Property Changes
- Arctic applications
- Volcano monitoring

**HEALTH**
- Infectious Diseases
- Epidemiology
- CVIEW (cardiovascular)
- Climate Change Effects

**SECURITY**
- Public Safety
- Counterterrorism (CBRNE)
- Preventive Measures
- Emergency/Disaster
- Preparedness & Response

**ENERGY**
- Conservation
- Optimization
- New Sources
- Advanced Systems

**AGRICULTURE**
- Soil Conservation
- Irrigation Monitoring
- Pest Control
- Harvest Management

**ENTERTAINMENT**
- Leisure
- Gaming
One Exploratory PLATFORM and APPLICATIONS

**ATHOS Platform for Human-Robotic Interaction**

*and its implementation within*

**AgriBrains Cooperative Robotic Network**

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**Generic, Reconfigurable Multiple Applications** (not only UAV+UGV+AUV)
- Research-Test-Demo
- Environment Energy
- Entertainment Health
- Security Space

**UAV+UGV (+AUV)**
- Agriculture
  - (mixed types: orchards, vineyards, vegetables, grains, livestock)
- Russia-first, Export-next
- Also a platform for R&D

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Agricultural Productivity Optimization using cooperative robots for sensing, analytics and control.
In its initial work, AgriBrains concentrates upon using individual units and clusters (groups) of UAVs for:
Monitoring of crop conditions: humidity (irrigation), pest control and ripeness.

Figure 1: eBee SQ drone for spectroscopic surveys
Figure 2: DJI eight-rotor drone with 10-liter capacity

Figure 3: Sentroid UAV illustrating air sampler, analytical results and control unit
AgriBrains (2)

UAVs already in very active use in agriculture worldwide -
Huge Economic Opportunities – for Developers and for Operators
AgriBrains (3)

Acquiring data is one thing. Producing Information is another. Getting the information to the right people and having them use it intelligently – still another major task!

The three-level monitoring system to recognize problem situations in a real time

Level 1: Group of satellites with hyperspectral cameras and required frequency and resolution of the fields up to 5-10 m (Resurs-P), Santinel (10-15 m) and Landsat (20-30 m)

Level 2: Unmanned drones (aircraft or helicopter), operating at altitudes of up to 1km, different ultra-high resolution in different spectral ranges and precision snap shots to the area up to 5 cm

Level 3: Field measurements carried out by precise static or mobile sensors (mounted on the working organs of tillers and units)
The Web is as important for implementing and operating a truly intelligent Agri-Robotic solution-environment as it is for communicating with humans.

**Smart Farming: The Idea of the Web-Based Solution**

- **Flow of Events**
  - Strategic Planning, Coordination and Visualization, Decision Making Support, Adaptation, Learning and Forecasting
  - Monitoring of Fields and Problem Situations Detecting in Real Time ("Left Part of Brain")
  - Managing machines and other Resources in Real Time ("Right Part of Brain")

- **Adaptation of Plans**
  - Swarm of Satellites with Hyperspectral Cameras
  - Provide Images Regularly (3 Times a Day) or By Request (On-Demand)
  - Service for Detecting Problems
  - Swarm of Drones for Detailed Analysis
  - Field Sensors in Selected Zones

- **Results**
  - Swarm of Machines and other resources
  - Strategic Planning of Resources
  - Adaptive Operational Scheduling of Machines
  - Coordinated Response for Solving Problems
  - Fast Reaction on Events
  - Decision Making Time is Minimized
Drawing upon what works well in other tech-apps ...

The Solution for Smart Farming: Multi-level distributed multi-agent system for precise farming based on "swarm-of-swarms" and Internet of Things concept

Swarm of satellites (S)

Swarm of drones (D)

Swarm of fields (F)

Swarm of machines (M)

Swarm of pesticides

Swarm of fertilizers

Swarm Intelligence for INDUSTRY 4.0 and Internet of things
Field inspection down to the leaves and the tomatoes and grapes on the vine ...

Smart Drone for Agronomy: UI for detailed analysis of problematic zones

User interfaces for Agronomist drone for UAV DJI Phantom3

Our Drone will give user the camera control for interactive inspection of leaves in a middle of the problematic fields
AgriBrains (7)

Mobile Apps for Farmers and their Robots, too ...

Real Time Resource Management with the Use of Mobile Applications for Machine Drivers

Real Time Machine Scheduling System based on Knowledge Base and Real Time Communication with Drivers via Mobile Devices (in future - fully autonomous unmanned machines)
Starting with large flat uniform fields is a good way to begin.

First developments and applications in Russia

- JSC “Rassvet” in Rostov region has wheat fields with more than 30,000 ha of surface fragmented in a smaller areas.
- The company uses top-level technology and John Deer equipment for wheat production and export sales.
- Specialists need to monitor these all fields covering large distances on a daily basis (more than 700 km a day).
- Software prototype was developed for monitoring fields with satellites and drones.
- First experiments were implemented successfully (see next slides).
Hyper-spectrum satellites and drones: 70 fields monitoring (www.agribra...
Multiple Directions for School-level, University-level, Post-Graduate-level Projects

♦ Differentiation and specialization for crop type variants
♦ Planting and harvest planning (info maps AI-recommendations)
♦ Seed planting – physical planting and follow-up for germination/replanting
♦ Fertilizer optimization – focus upon reduction of excess use and cost

♦ Frost control – an emerging problem given the trend in non-linear climate change
♦ Irrigation optimization – focus upon balance in hydration
♦ CB (chem-bio) sensing and monitoring – focus upon toxins, bacteria and viruses
♦ Pest control – focus upon emerging insect and micro-fauna due to climate change

♦ Sugar content – a critical area for fruits and for crops used in beverage production
♦ Ripeness and harvest readiness – focus upon increasing yield and turn-around
♦ Tree and bush pruning (management and planning)
♦ Predator control (e.g., birds, foxes, wolves) – focus upon deterrence
Agricultural Productivity Optimization using cooperative robots for sensing, analytics and control

- Robot networks (UAV, ULV, AUV) both human-assisted and autonomous control
- Diverse array of CBR (chem-bio-rad) and EM (electromagnetic) multi-spectral sensors +
- Electro-mechanical actuators (spray, drop, pick, other actions)

- Onboard and mobile, as well as manually-delivered

- Dynamic mobile operation, and static-placed stationary operation

- “Plug-n-play” device independence for all platforms including applicability to other systems (e.g., aircraft, helicopters, etc.)

- Data acquisition and integration with satellite-based and other telemetry and knowledge sources

- Analytics employing human expertise and synthetic (AI, machine-learning) intelligence

- BOINC-based distributed processing for massive computational tasks

- Data management (DBMS) and knowledge representation, distribution, data mining
AgriBrains (12)
Project Development Phases

Phase I
Commercially-available UAV systems (RU, CN, FR)
Ready-to-use software, ready-to-fly robots

Focus on (1) SYSTEMS issues, challenges, solutions and (2) Adaptive Devices (e.g., sensors, new spectroscopic analysis, new GIS methods, and actuator units)

Phase II
Innovations in Methods of Use for Agriculture Applications

Improvements to Software, especially use of AI (SI) machine-learning and data integration

Improvements to Hardware, especially in UAV electromechanics

Phase III
Innovations to UAV design, control software, human-interfaces, and peripheral devices (e.g., new onboard spectroscopic instruments and “sensor fusion”)
PROJECT Branches and Spin-Offs

[1] UAV and Robotics Project Types (EXAMPLES including for Youth Projects)

• Multiple UAVs deployed over a region to predict in advance and to monitor actual conditions of flooding, drought, forest fire, thaw, and pest dispersion
• UAVs transporting necessary instrumentation and supplies to persons living or working in remote, inaccessible, and dangerous situations
• UAVs and UGVs operating to diminish the spread of mosquitoes
• UAV-type robotic vehicles operating in deep space as part of an ASTRIC-type planetary defense network for deterrence and deflection of an asteroid
• UAV and UGV cooperative operations pertaining to targeted water control and pest control for agriculture
• UAVs deployed in the dynamic repositioning of lightweight VAWT (vertical airfoil wind turbine) generators, for optimizing the generation of electricity
• UAV technologies deployed in the dynamic repositioning of flexible thin-foil photovoltaic panels and sheets, for optimizing the generation of electricity
• UAVs deployed for the visual and auditory enhancement of many types of spectator sports, concerts and festivals
• UAVs deployed for the safety of airports, mass-transit operations, dense urban areas
→ more →
UAV and Robotics Project Types

- UAVs used within a variety of augmented-reality gaming experiences including GPS-relevant adventure games

- UAVs deployed to enhance safety and security for citizens, especially women and children, in areas subject to threats from criminals including sexual predators

- UAVs deployed as cooperative networks for a variety of tasks to minimize and to response after emergencies such as floods, earthquakes, tornadoes, hurricanes, fires

- AUVs deployed for increasing efficiency of aqua-farming operations

- UGVs and AUVs deployed for increasing efficiency of hydroponic farming operations

- UAVs and UGVs deployed for yield optimization and increased efficiency and safety in the operation of mines and also metals reclamation facilities

- UAVs deployed in space for construction of deep-orbit, lunar, or planetary habitations, mining, and manufacturing facilities
EXAMPLES – Well-Defined Prior Projects (2000-present) that can be extended

§ EcoVita (Arctic-focus (Siberia, Far East Russia, Northern Canada) environmental sensing and monitoring (toxic chemicals including organophosphates)
§ CUBIT-Delta (PCR-based rapid detection and diagnostics of infectious bacterial and viral diseases, particularly those capable and likely of generating severe pandemics (e.g., influenza, Ebola, SARS, MERS, and other viral diseases)
§ Coastal Property Monitoring (use of UAV and UGV systems to monitor, measure, compare, evaluate coastal properties and features in expectation and in response to storms and rising sea levels)
§ ASTRIC and MOSES (space-based robotics for planetary defense from asteroids)
§ Platforms that can be used to test and demo different micro/nano sensors and actuators for many other research teams and their projects
§ MASK (also implementation using KOIN – focus on micro-film cams and lenses and the MASK architecture for combined, integrated VR and AR (360-degree omnivision)
§ SELDON and Prediction Engine (predictive analytics and data mining)
§ Biosphere for space habitation and agriculture (PodAtrium basis)
§ Permaculture R&D (agricultural improvements for Earth and Space)
§ Platform for test/demo of KyberShield and the basis of I-Bank (mobile, distributed “untouchable” servers) and other distributed cryptosystems
§ I-Trans model of hybrid interurban auto/truck and rail travel (ferry-like operations)
§ Platform to test different Quantum Computing (QC) models and systems
Keep in mind ---- this is also the TESTBED for Developing Robotics & Complex Systems OLYMPIAD (multi-level) STANDARDS and DISCIPLINES for ROBOTICS EDUCATION

ATHOS Platform
Generic, Reconfigurable
Multiple Applications
(not only UAV+UGV+AUV)
Research-Test-Demo

AgriBrains
UAV+UGV (+AUV)
Agriculture
Russia-first, Export-next

Robots
Robotics
Olympiad
Projects
(e.g., Astro-Robotics)

Awards ➔ Internships
“Guild” Programs

Faculties &
Curricula of
Robotics

More & Better Jobs, Contracts,
and Investment Equity Income

Students
(classes 1-11)

School
Teachers

University
Students

Professors

Mentors &
Experts

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Enabling Students, Mentors, Researchers, and Commercializers to work in Augmented Real + VR modes

“Open Lab” (aka “Virtual Lab”)
“Open Lab” (aka “Virtual Lab”)

One coordinative hub --- state-of-art omnipresence capability through the internet

Capability to engage and incorporate online any laboratory at the “hub” institution and progressively at any other institution worldwide

Capability to incorporate and interface any instrumentation, equipment, machines (examples)
Microscopes, spectroscopy instruments (analytical chemistry, biology, medicine)
UAV, UGV, AUC robots – in the workshop or in the field

Any remote person (student, mentor, collaborating researcher) can have Virtual Real-Time On-Site Presence and Activity with instruments and peers

Not only for viewing but for interacting and controlling

A showpiece and a platform for demonstrating and also testing - for all the companies producing the components for this – software, internet, analytical instruments, all.
“Open Lab” (aka “Virtual Lab”) - EXAMPLE

Virtual MCU is integrated in the Distance Lab and accessible over Internet

DISTANCE LAB 2.0

VIRTUAL MICRO CONTROLLER

HOME LAB KITS

REMOTE LABS / ROBOTS

NETWORK OF EXCELLENCE & MATERIAL

Real Applications, in form of Remote Labs, are accessible by the Distance Lab

Virtual MCU behaves exactly like Kit, but fully virtualized

Robots are based on HomeLab hardware

Teaching on robotic applications

Teaching on virtual hardware
Keep in Mind --- HOW ALL THIS RESEARCH + EDUCATION (Internship) SERVES The Socioeconomic Problems We Address and Solve

This is often a “missing element” within STEM Research and Development, and in our present times, this is a critical dimension for our future societies.


[2] Social Disorientation, Ennui, Disconnection and Substance/Social Abuse among Youth and consecutive next-generations


[4] “Bright Kids” Undiscovered and Unrecognized, and not given opportunities to use their natural talents, leading to their frustrations and society's disadvantage
Cooperative R&D

Research

Extreme and Uncertain Complex Systems

Universities

Int'l

Russia

Companies and Institutions

Int'l

Russia

MIRNOVA ACADEMY

Teaching

Training

Innovating

Students (Youth)

University Students

Teachers

Professors

Experts

Research Results

Intellectual Properties

Spin-off (start-up) Companies

Papers

Conferences

Publications

Licenses

Patents

Tech Transfer
Expected Outcomes

What We Expect the cooperative activity to produce together:

**Scientific (STEM)** – results of practical as well as theoretic value

**Commercial** – transferable and licensable to international range of companies

**Educational** – for the participating University Students and Faculty as well as for pre-university students at all levels

**SOCIAL** – an engaging and attractive force for YOUTH in Russia and Beyond, something that pulls in young people and prepares them for careers in STEM but also with project management and teamwork skills development through internships and “hands-on” experience
MIRNOVA ---- Comprehensive Integrated View ---- МИРНОВА

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Academy

EDUCATION
S.T.E.A.M. (STEM)
PROGRAM

COMMUNICATION
PROGRAM

RESEARCH
PROGRAM

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“Alpha” PROJECTS

Institute for
Innovative Study

Private Non-Profit
Organization

Theoretical and Applied
Fundamental Research

- Physics
- Mathematics
- Quantum Computing
- Biomedicine
- Space Sciences

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Multi-level, multi-student, multi-year
Integrated S.T.E.A.M. Projects with
training in teamwork, discipline,
project management, and business
development principles

Commercialization:
Incubator/Accelerator of
New Entrepreneurial Companies
Technology Transfer
Licensing

Private and Public
For-Profit Companies
(e.g., ABVGD Group)

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“Beta” PROJECTS

Private For-Profit
Company

“Beta” PROJECTS

Tutoring to
Individuals/Groups
through schools,
universities,
youth/leisure centers,
companies,
and private
arrangements

Each tutoring activity involves
a “mini-project”

Mirova Academic
Tutorship Consortium
(MATC)

Private For-Profit
Company

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Tutorship Consortium
(MATC)

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Company

- Publications (print and
  online)
- Seminars, Workshops,
  Talks (onsite and online)
- Special Interactive
  Events (onsite and
  online)
- Internet SocialMedia
  Channels (articles, blogs,
  videos, project and
  product demonstrations)

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Private Non-Profit
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Tutoring to
Individuals/Groups
through schools,
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companies,
and private
arrangements

THEORETICAL AND APPLIED
FUNDAMENTAL RESEARCH

- Physics
- Mathematics
- Quantum Computing
- Biomedicine
- Space Sciences

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Gradual development of collaborative team and organizational matrix
~~~~~~~~~~
Seminars
Papers
Books
~~~~~~~~~~
“Quantum Relativity, Biology and Computing”

[1] **Agri-Brains** (UAVs + UGVs in Agriculture)

[2] **CryptoK** -- Cryptocurrency and Cybersecurity


[4] **ASTRIC** (space robotics for asteroid intervention and space industry)

[1] **Channels** (multiple) – articles and videos

[2] “**Open Lab**” - real-time online and virtual reality participation in “Alpha” and “Beta” Project activities & demos

[3] “**Ars Bio**” -- online and onsite exhibits and performances


[1] **Middle-school-level programs** with Leisure Centers and Schools

[2] **Programs for corporate staff** and prospective new employees

[3] “**Training of trainers**” for university-level students and graduates

[4] **Licensed distribution** of tutoring material through other companies worldwide
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MIRNOVA is based in Zelenograd, Moscow Oblast, Russia and also with presence in USA, EU and Far East.