BIPOLAR Advisory Board Review

Kick-off Meeting

Katarzyna Kaczmarek-Majer
k.kaczmarek@ibspan.waw.pl

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Agenda

1. About BIPOLAR project
2. Advisory Board
3. Objectives
4. Team
5. Research
6. Use cases
7. Dissemination
8. Deliverables and Milestones
9. Other indicators
10. Risk assessment

BIPOLAR project: ***Bi****polar disorder* ***p****rediction with sens****o****r-based semi-supervised le****a****r****n****ing*

Small Grant Scheme

Norway grants

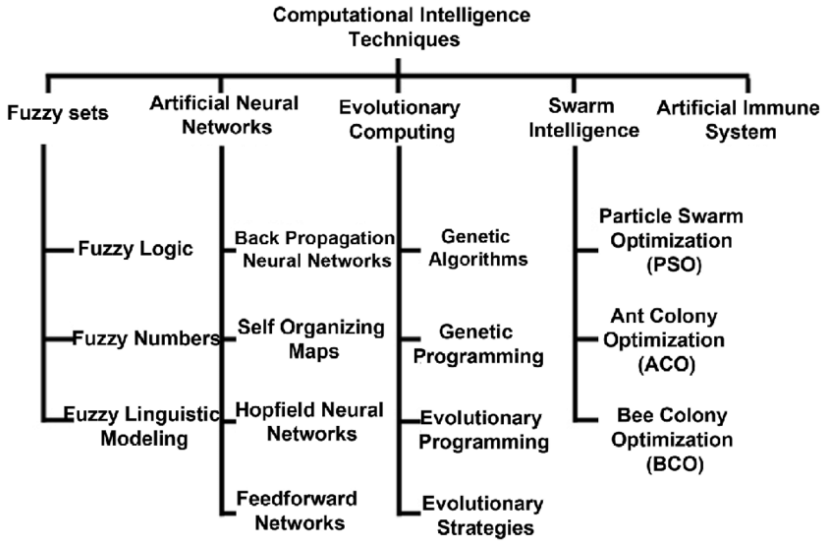
BIPOLAR aims at the development of new predictive sensor-based computational methods as open source software package addressing bipolar disorder diagnosis and monitoring.

Time: 01.01.2022 – 31.12.2023
Total funding: 896250 PLN
Applicant: Instytut Badań Systemowych Polskiej Akademii Nauk

Key novelty

The key novelty and strength of the BIPOLAR project lies delivering a **research-based open-source software package enabling semi-supervised learning for bipolar disorder episode prediction**. BIPOLAR has access to **two digital anonymized datasets** collected from sensors of BD.

BIPOLAR integrates elements from **computational intelligence and signal processing** to support the challenging problem of monitoring bipolar disorder patients.



Source: Sadeghi et al. 2017: Recommender Systems Based on Evolutionary Computing: A Survey

Advisory Board

An **International Advisory Board** (IAB) is established involving key external stakeholders (including psychiatrists) and will guide the project on how to develop and sustain the BIPOLAR software and facilitate its adoption.

[1] **prof. Giovanna Castellano (GC)** from the University of Bari with expertise in **semi-supervised learning and data streams** will advise for WP3 and WP5;

[2] **prof. Maria Ganzha (MG)** from Faculty of Mathematics and Information Science, Warsaw University of Technology, expertise in **internet of things** (IoT) will advise for WP3 and WP5;

[3] **prof. Eulalia Szmidt (ES)** from the Systems Research Institute Polish Academy of Sciences, with expertise in modeling imprecision with **fuzzy set and systems** will advise for WP4;

[4] **prof. Svetlozar Haralanov (SH)** from the Medical University of Sofia, Department of Psychiatry and Medical Psychology with expertise in **psychiatry** will advise for WP2 and WP1 concentrating on dissemination activities on the international level.

[5] **dr Monika Dominiak (MD)** from the Institute for Psychiatry and Neurology in Warsaw, expertise in **psychiatry** will concentrate on dissemination activities in Poland and on the international level;

Objectives

Objectives and key result	Initial KPIs
O1: **Feature engineering of behavioural and acoustic data collected from sensors**: To develop and evaluate data aggregation and feature retrieval methods that can be utilized to support: (a) formulation of user-oriented predictive markers (e.g., daily variability of energy); (b) selection of most informative features in BD prediction.	- predictive power and interpretability of features tested in use cases
O2: **Modeling uncertainty of psychiatric assessments**: To develop and evaluate computational methods that can be utilized to support retrieval of information from the psychiatric assessments (e.g., depressive symptoms). Finding best ground truth.	- performance time - model diagnostics
O3: **Predictive software engineering**: To develop and evaluate uncertainty-aware, sensor-based and semi-supervised prototype for retrieval of new information about the state of bipolar disorder patients and prediction of their state change (metrics used for performance evaluation)	- performance (metrics such as acc, prec, recall, FP rate calculated in cross-validation and out-of-sample) evaluated and compared to SoTA algorithms
O4: **Use cases**: To demonstrate the developed BIPOLAR prototype in two real-life use cases: (1) sensors from smartphone for monitoring of depression and mania (2) locomotor sensors for monitoring of depression	- completion of use cases, calculation of KPIs from specific scenarios
O5: **Exploitation and dissemination**: to generate a high level of impact and to disseminate and exploit project results. The planned dissemination and exploitation activities will be regularly reviewed and consulted with International Advisory Board (IAB)	- publications - regular updates github repository - exploitation plan

Katarzyna Kaczmarek-Majer

Katarzyna Kaczmarek-Majer is an Assistant Professor at the Systems Research Institute of the Polish Academy of Sciences. Her research interests cover time series analysis, soft computing, computational statistics, sensor data analysis and medical applications.

Olga Kamińska

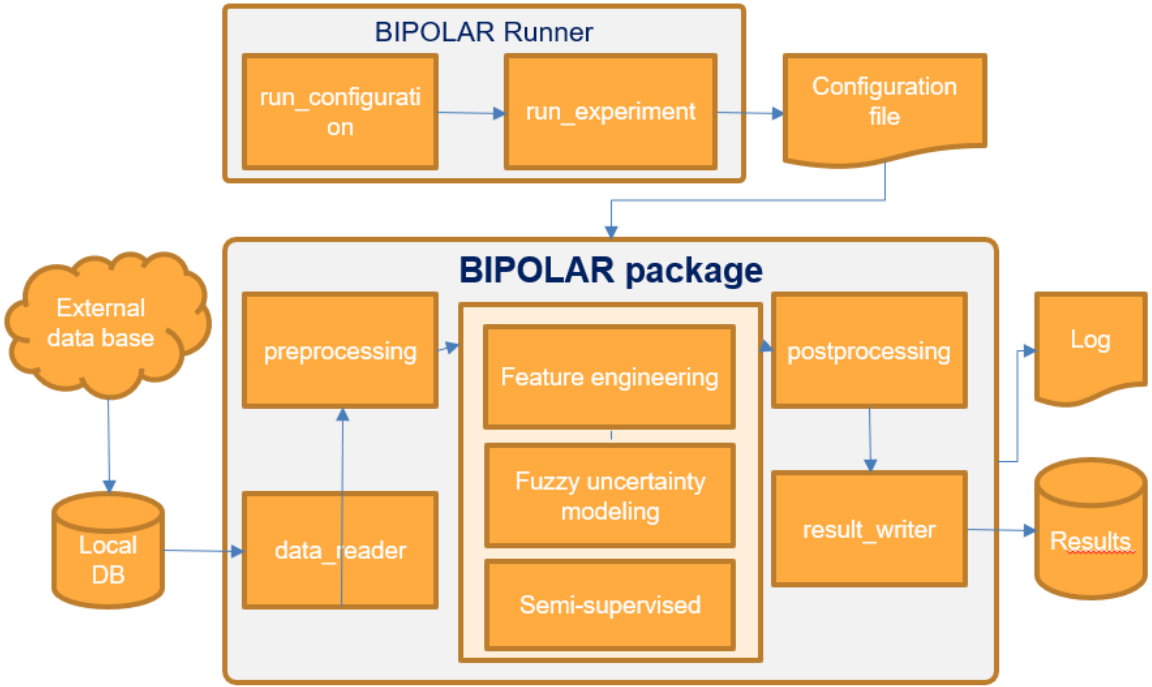
Data Scientist and PhD. Candidate at Systems Research Institute of Polish Academy of Science. Graduate Master Degree of Computer Science at the Poznań University of Technology. Passionate about applying Artificial Intelligence into HealthCare Industry. Sport freak in free time.

Kamil Kmita

My name is Kamil - I am a statistician/data scientist. I graduated from Warsaw University of Technology (Faculty of Mathematics and Information Science) in 2018 (MSc in Mathematics with specialization in Mathematical Statistics and Data Analysis).

Main result

BIPOLAR will deliver a working prototype (Figure illustrates its architecture) that will be made available under open access licence and will impact outside of the information sciences communities (in any area where sensors can support mental illnesses).



Architecture overview of the BIPOLAR software package

ITPsychiatry/bipolar (github.com)

Work plan

Signal processing encapsulates techniques for analysis, processing and extracting features from sampled signals, such as data streams collected from sensors.

Computational Intelligence (CI) is a subarea of broadly meant artificial intelligence (AI) for advanced information processing consisting of nature-inspired computational methodologies such as, e.g., fuzzy systems, neural networks, evolutionary systems, probabilistic methods. CI places emphasis on the development of real world applications.

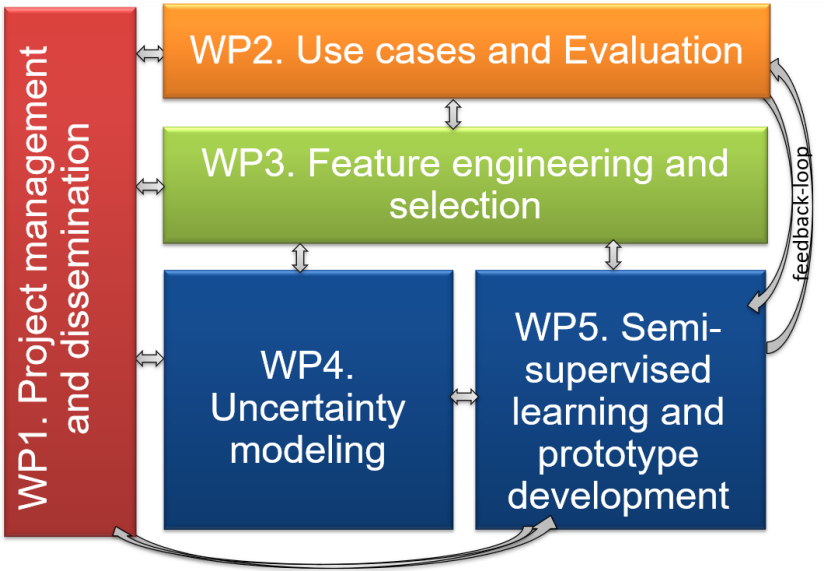
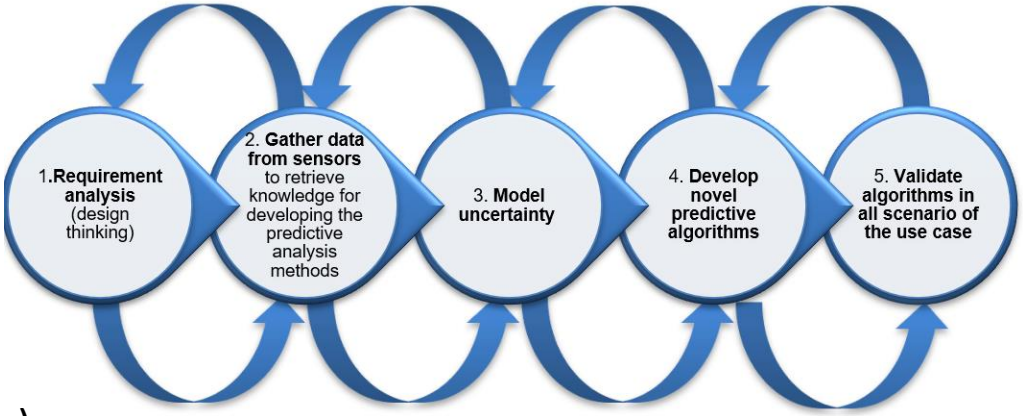


Figure 2.1. BIPOLAR work package organization

Research approach

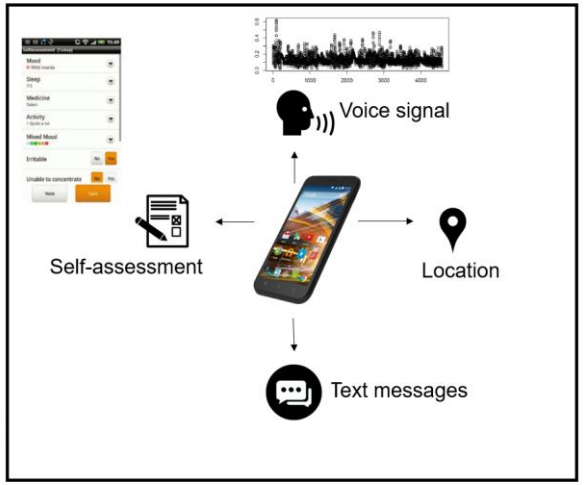
There will be 5 main phases in the piloting on both use cases



Requirement analysis (design thinking);
Aggregate data from sensors and select features for developing the predictive methods.
Model the uncertainty about psychiatric assessments (severity of depressive and manic symptoms) and the imprecision of the sensor measurements (if relevant);
Develop novel predictive algorithms resulting from knowledge retrieved from sensors;
Run tests and validate algorithms in all scenarios of the use cases.

Use Case #1

Smartphone sensors for monitoring of depression and mania. Data collected by Institute of Psychiatry and Neurology, Warsaw



Scenario 1: Intelligent identification of healthy state (euthymia). Scenario deals with computing and optimal selection of most discriminative features from smartphones including acoustic and behavioural features and intelligent identification of mental state of health. Aim of the scenario is early identification of the start of euthymia period and monitoring of stability of patient condition, in order to detect deviations from the stable period and generate alerts for abnormal behaviour.

Scenario 2: Prediction of shifts from euthymia to depression with an adjustment to individual patients. Scenario deals with semi-supervised learning using smartphone data for predicting shifts from euthymia to depression. The aim of this scenario is to move from traditional subjective psychiatric assessment towards objective real-time monitoring of increasing depressive symptoms. Personalized approaches will be developed due to high variability between patients.

Scenario 3: Prediction of shifts from euthymia to mania and mixed states. Scenario deals also with semi-supervised learning using smartphone data for predicting shifts from euthymia to the manic and mixed states. Patients with manic symptoms show a significant drop out rate and special attention to missing data shall be given (some patients stop using sensors). The aim of this scenario is to extend the semi-supervised approach developed in scenario 2 to account for the missing data and improve the early prediction of the manic/mixed states.

Use Case #2

Locomotor sensors for monitoring of psychomotor disturbances. University Hospital for Neurology and Psychiatry St. Naum in Sofia

Stepping-test computerized ultrasonic cranio-corpo-graphy

Scenario 1: Stratification of depression states according to their locomotor inhibition or activation with an adjustment to individual patients. Scenario deals with semi-supervised learning using locomotor data for identifying latent bipolarity, having in mind that the locomotor overactivation during depressive episode predicts shifting toward manic or mixed state. The aim of this scenario is to measure the spatial-temporal equilibriometric movement patterns during one-minute execution of the stepping test of Unterberger with subsequent computerized analysis in order to stratify the depression patients into subgroups with various degrees of locomotor inhibition or activation, thus predicting the treatment response and the suicide risks.

Scenario 2: Identification of individual locomotor abnormalities with objective sensor markers. This scenario deals with monitoring abnormal behaviors during the personalized treatment. The aim of this scenario is detecting objectively measurable abnormalities at a single-patient level with subsequent objective monitoring of their dynamics (toward improvement or worsening) during treatment with antidepressants, antipsychotics, mood stabilizers, or various combinations of them.

Results

Here you will find all communication material published by BIPOLAR.
Results of BIPOLAR will be made available under open access licence.

6.2. Deliverables

DEL. NO	DELIVERABLE NAME	WP NO	TYPE	LEVEL	DELIVERY DATE	DOWNLOAD
D1.1.	Recruitment process completed. Team and IAB established.	1	R	PUBLIC	M3	
D1.2.	BIPOLAR website	1	OTHER	PUBLIC	M3	
D1.3.	IPR management document	1	R	PUBLIC	M12	
D1.4.	Dissemination Plan	1	R	PUBLIC	M6	
D1.5.	Exploitation Plan	1	R	PUBLIC	M18	PDF
D1.6.	Annual reports	1	R	PUBLIC	M12, M24	

27 deliverables in total (page 1/2)

Del. No	Deliverable name	WP No	Type	Level	Delivery Date	Download
D1.1	Recruitment process completed. Team and IAB established.	1	R	Public	M3	
D1.2	BIPOLAR website	1	Other	Public	M3	
D1.3	IPR management document	1	R	Public	M12	
D1.4	Dissemination Plan	1	R	Public	M6	PDF*
D1.5	Exploitation Plan	1	R	Public	M18	
D1.6	Annual reports	1	R	Public	M12,M24	
D1.7	Dissemination and exploitation Report	1	R	Public	M24	
D2.1	Use cases with psychiatric scenarios	2	R	Public	M9	
D2.2	Evaluation plan	2	R	Public	M9	
D2.3.	Final technical evaluation	2	R	Public	M24	
D2.3	Initial use case evaluations	2	R	Public	M12	
D2.4	Final use case evaluations	2	R	Public	M24	
D3.1	Initial feature preprocessing (software component)	3	O	Public	M6	
D3.2	Final feature preprocessing (software component)	3	O	Public	M12	
D3.3	Guidelines to BD feature preprocessing	3	R	Public	M12	
D3.4	Initial features selected	3	R	Public	M12	
D3.5	Final features selected (software component)	3	O	Public	M18	
D3.6	Guidelines for selecting features in BD scenarios	3	R	Public	M18	

27 deliverables in total (page 2/2)

Del. No	Deliverable name	WP No	Type	Dissemination Level	Delivery Date	Download
D4.1	Interval sets for affective states modeling (software component)	4	O	Public	M18	
D4.2	Fuzzy sets for affective states modeling (software component)	4	O	Public	M24	
D4.3	Interval and fuzzy approach to affective states modeling	4	R	Public	M24	
D5.1	Requirement analysis	5	R	Public	M9	
D1.2	Initial BIPOLAR package Architecture	5	R	Public	M9	
D1.3	Review of existing models and methods used for scenarios of use cases	5	R	Public	M12	
D1.4	Final BIPOLAR package Architecture	5	R	Public	M18	
D1.5	Fuzzy semi-supervised module for bipolar disorder (Software component)	5	O	Public	M24	
D1.6	Integrated BIPOLAR software package (Software component)	5	O	Public	M24	

Milestones

Milestones	
Psychiatric scenarios defined and datasets specifications complete (verified specification of 5 scenarios complete, datasets for experiments available, list of use case specific KPIs)	M1.1 (9M)
Availability of preliminary use cases evaluations (verified with evaluation of at least 2 out of 5 scenarios, comparative analysis with SoTA methods, vailability of guidelines for improvement (feedback loop) for WP2-WP4)	M1.2 (12M)
Use cases evaluated - Final assessment (verified with evaluation of all 5 scenarios, comparative analysis with SoTA methods. Availability of final use cases evaluations, comparative analysis of BIPOLAR results for episode prediction vs. selected benchmark methods. Expected improvement from 5% (average) to 15% (excellent) in at least 3 evaluated scenarios).	M1.3 (24M)
Set of most predictive features selected (verified with evaluation in at least 2 scenarios, comparative analysis with SoTA feature elimination methods. Expected improvement from 10% (average) to 30% (excellent) in at least 2 evaluated scenarios of the two use cases towards randomly selected subset of features.	M2 (18M)
Affective states modeled as fuzzy numbers (verified with evaluation of at least 2 scenarios, comparative analysis with crisp methods)	M3 (24M)
Requirements and BIPOLAR initial design (verified systematic SotA complete, requirements analysis complete, architecture design)	M4 (9M)

Other indicators

Table 1.3. – Research key challenges and expected TRLs (project start/end) for each of the modules

Module	Key challenges	TRL
Module for data aggregation and bipolar feature retrieval	Aggregation of sensor data leads to skewed and asymmetric distributions, outlier detection	2/4
Module for assignment of imprecision to digital data using affective symptoms	Identification of patterns in objective data related to the fluctuations in the intensity of depressive and manic symptoms at a single-patient level	0/2
Module for uncertainty aware semi-supervised prediction	Handling missing data in incremental approaches Reduction of false alarms	2/4

VII. WSKAŹNIKI / INDICATORS

Nazwa wskaźnika / Indicator	Jednostka miary / Unit of measurement	Wartość bazowa / Baseline value	Wartość docelowa / Target value
Peer-reviewed scientific publications submitted	Number	0	8
New products/technologies developed	Number	0	0
Registered applications for Intellectual Property Protection	Number	0	0
Polish researchers supported	Number	0	4
Polish female researchers supported	Number	0	3
Female researchers going abroad for research	Number	0	2

Risk assessment

Main risks are summarized in the following table (likelihood/impact).

WP	Main risks	Risk mitigation measures
1	**Insufficient exploitation of results (L/M)**	Close cooperation of experts in the medical and research domains guarantees that the project results will be directly disseminated, and available to potential end-users.
2, 5	**Performance metrics not informative (L/M)**	Augment the indicators with medical advise of the IAB
2	**Difficulties in evaluation of use cases and testing (M/H)**	The implementation strategy includes a feedback loop, to ensure that information gathered from the use cases is incorporated into the software and methodology, and preventing misalignment between developed solutions and the real-life context.
3	**Workload required to process features from sensor data is bigger than expected (M/L)**	Decrease the number of sensor sources used in use cases. Focus on one or two, in order to deliver a working solution, extendible with other data sources and able to solve the key problem stated within this project that is uncertainty-aware prediction
3	**Technical problems related to remote data: bandwidth low, scope too broad (L/M)**	Focus primarily on local customized copy of data. Such data may be smaller in size, and would not include latest updates. Consult with IAB (GC and MG are experts in processing large data).
3, 4, 5	**Resources are not enough for ambitious research ideas (M/M)**	The focus will be put primarily on the components necessary for the implementation of use cases, in order to deliver a complete working solution with at least a minimal set of features.
all	**Resources related risks: personnel underperforming, personnel leaving (L/M)**	The PI will try to balance research freedom and creativity versus efficiency and a disciplined focus on results and application to keep the team members motivated and effective. Synergies with medical experts in use cases shall improve the overall motivation and satisfaction from work.
4, 5	**Targeted performance is not reached in using semi-supervision and fuzzy set theory (L/M)**	Alternative methods of modeling imprecision will be explored, including intuitionistic fuzzy sets, rough sets. Alternative predictive methods will be explored, including neural networks and benchmark classifiers. The priority is given to explainable models.

Thank you