KHMELNITSKY NATIONAL UNIVERSITY
SYSTEM PROGRAMMING DEPARTMENT

INFORMATION TECHNOLOGY OF PREDICTING THE CHARACTERISTICS AND EVALUATING THE SUCCESS OF SOFTWARE PROJECTS IMPLEMENTATION

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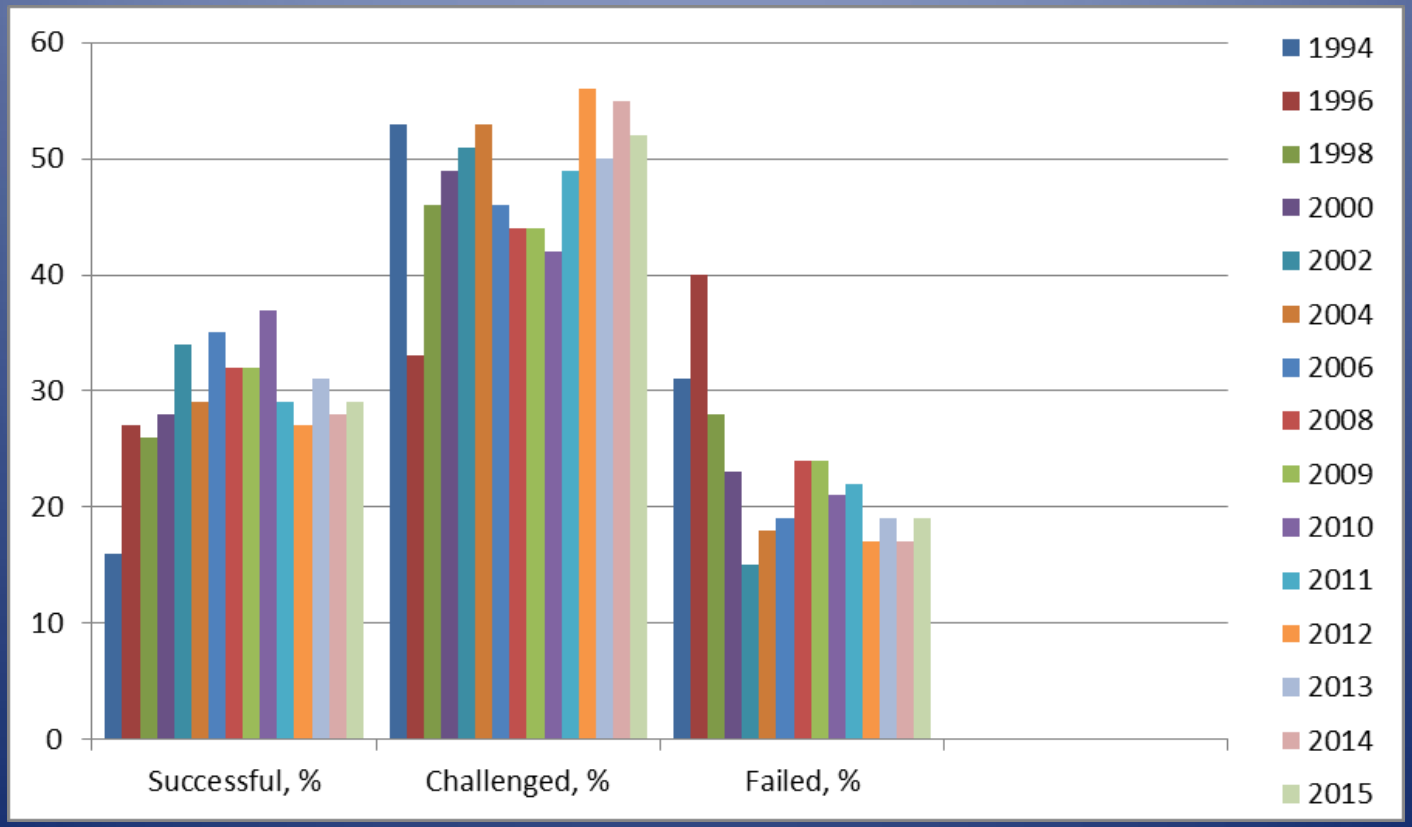
Actuality of the research

At the present definition of software quality, **if the goals of the project don't meet the needs of users, the software will not be qualitative and successful**, even if the modern technologies and the most qualified developers were involved to its development.



Almost all the causes of software incidents and accidents are latent in the SRS.

The vast majority of software accidents arises from false requirements but not from coding bugs.

Software versions, written by the different developers for the same SRS, contain the number of the common bugs associated with errors or inaccuracies of requirements.

The main causes of the failure of software projects are the misconceptions of project managers on real deadline and budget for providing the user functional requirements.

Then the quality and success of the software project implementation depend on the SRS, resulting in the need to deepen the analysis of specifications.

Then the **actual task** is the ability to evaluate the potential success of software project implementation based on the software project characteristics (project cost, duration, complexity, usability, cross-platform, quality), the predicted values of which can be obtained by analyzing the SRS indicators (*success of software project implementation* is timely execution of software project within the allocated budget and with realization of all necessary features and functionality).

The existing methods and tools of SRS analysis and software project characteristics determination **are not acceptable for the quantitative evaluation of the software project characteristics** based on only requirements analysis and for evaluating the success of the software projects implementation.

So the **purpose of this study** is the development of the information technology (model, method and tools) of predicting the characteristics and evaluating the success of software projects implementation based on analysis of the SRS.

6 types of software projects: Web-applications, mobile applications, e-learning applications, applications for statistics and accounting, automated systems, information systems

30-50 tasks for each type of software projects –

total 200 tasks

1-3 SRS (by the various developers) for each task –

total 410 SRS

1-3 finished applications (written by the analyzed SRS) –

total 410 applications

Course projects in discipline "Technology of software systems design" (*3% of all projects*; moreover only student projects, that were devoted to solving the real-world tasks and were successfully applied in different industries)

Diploma papers (*7% of all projects*; moreover only student projects, that were devoted to solving the real-world tasks and were successfully applied in different industries)

Projects of students scientific group «SOFTWARE» (*5% of all projects*; moreover only student projects, that were devoted to solving the real-world tasks and were successfully applied in different industries)

SRS and applications of the software companies of Khmelnitsky (“Avivi”, “Smile”, LLC «STU Electronics»)

Information Technology of Predicting the Characteristics and Evaluating the Success of Software Projects Implementation (ITPCES)

Information Technology of Predicting the Characteristics and Evaluating the Success of Software Projects Implementation (ITPCES)				
Object – the success of software projects implementation	**Goal** – predicting the characteristics and evaluating the success of software projects implementation	**Model** –neuronet model of predicting the software projects characteristics based on the SRS analysis	**Method** – method of evaluating the success of software projects implementation based on analysis of SRS (MESSPI)	**Tools** – intelligent system of predicting the characteristics and evaluating the success of software projects implementation (SPCES)

The structure of ITPCES

The neuronet model of predicting the software projects characteristics based on the SRS analysis:

The input data for ANN:

R1={Tv, Qv, Sa, Qcs, Sc},

where Tv – predicted realization time, Qv – quantity of performers, Sa – predicted quantity of users, Qcs – quantity of software components, Sc – predicted size (LOC);

R2={Cos, Cdb, Cc, Cdt, Cud, Sud},

where Cos – cost of used operating systems, Cdb - cost of used databases, Cc – cost of used compilers, Cdt – cost of development tools, Cud – quantity of user documentation pages, Sud – cost of user documentation

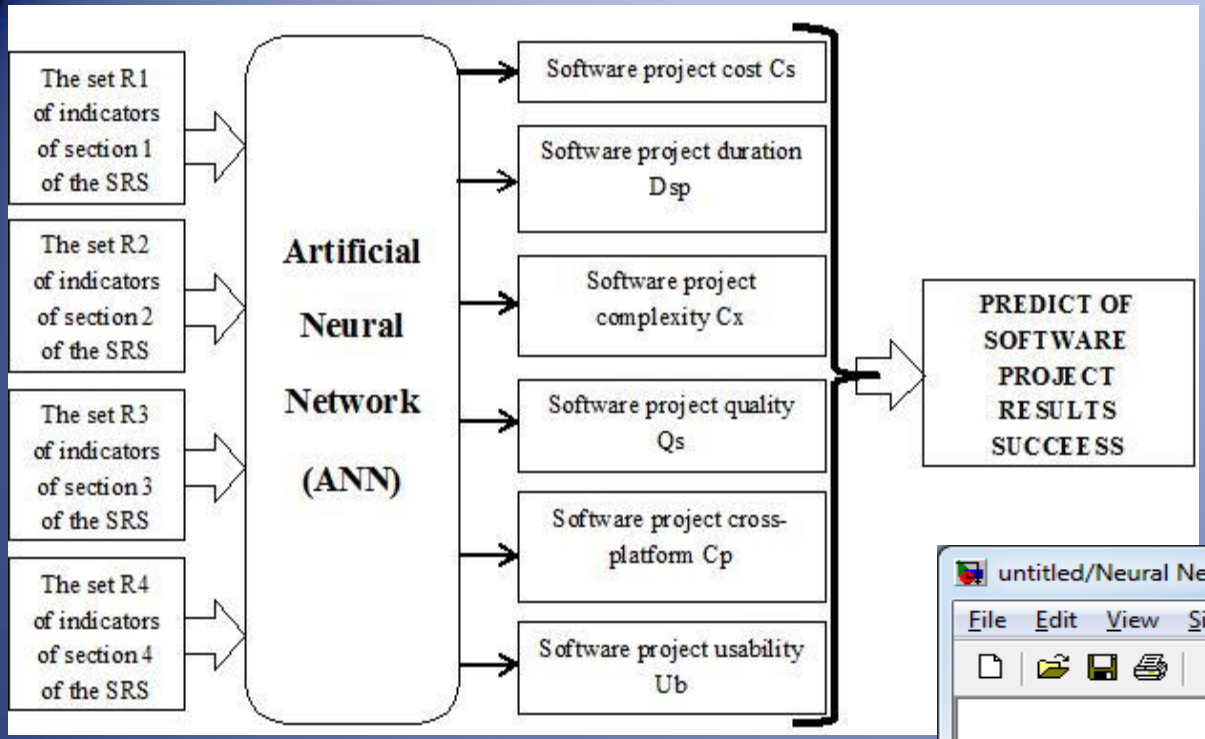
R3={Qfr, Cfr, Qa, Cb, Cui, Qmi, Cmi, Qai, Cai, Qci, Cci, Qnfr, Cnfr},

where Qfr – quantity of functional requirements, Cfr – cost of functional requirements, Qa – quantity of algorithms, Cb – average predicted cost of bug, Cui – cost of user interfaces, Qmi – quantity of intermodule interfaces, Cmi – cost of intermodule interfaces, Qai - quantity of hardware interfaces, Cai – cost of hardware interfaces, Qci - quantity of communication interfaces, Cci – cost of communication interfaces, Qnfr – quantity of non-functional requirements, Cnfr – cost of non-functional requirements.

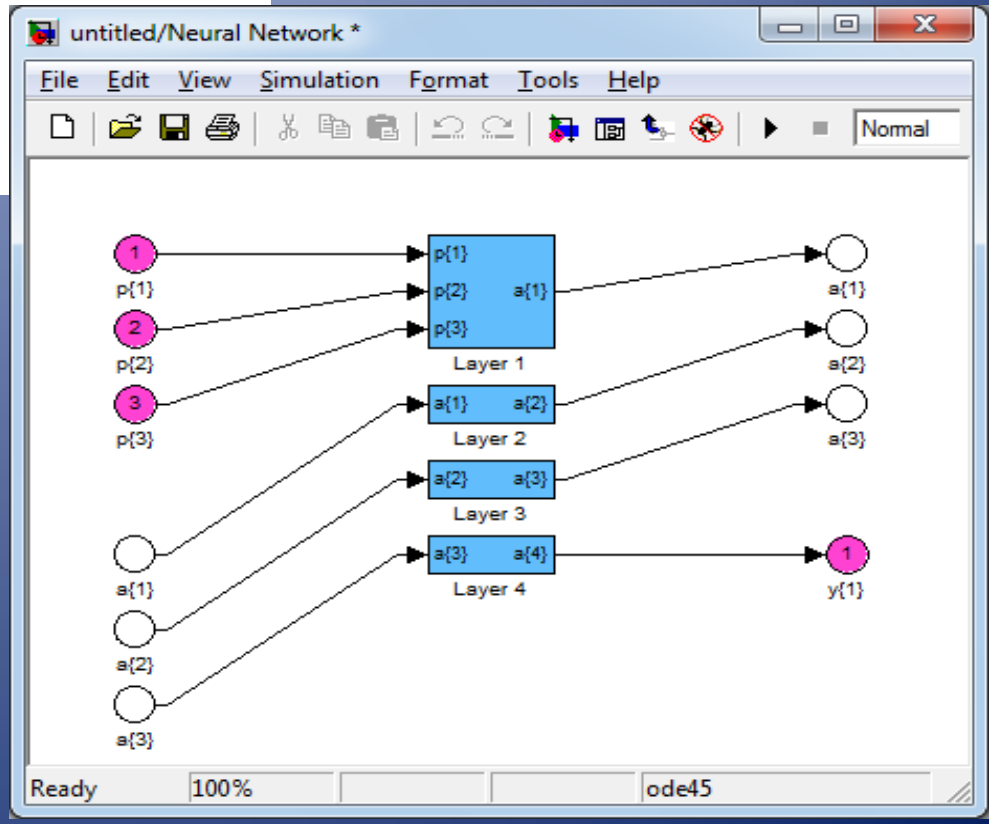
The result of ANN functioning:

SCH={Cs, Dsp, Cx, Cp, Ub, Qs},

where Cs – software project cost, Dsp – duration, Cx – complexity, Cp – cross-platform, Ub – usability, Qs – quality.



The concept of neuronet prediction of characteristics of software project based on the analysis of SRS



The structure chart of ANN layers

The method of evaluating the success of software project implementation based on analysis of SRS (MESSPI):

1

- Neuronet prediction of characteristics of software project based on the analysis of SRS. The result of this stage - **SCH={Cs, Dsp, Cx, Ub, Cp, Qs}**, Cs € [0..1], Dsp € [0..1], Cx € [0..1], Ub € [0..1], Cp € [0..1], Qs € [0..1], where 0 – insufficient data for prediction of the characteristics (in this case MESSPI doesn;t work), 0.08 – characteristics negative affects on the success of software project implementation (high cost, duration, complexity, low usability, cross-platform, quality), 1 – characteristics positive impacts on the success of software project implementation (low cost, duration, complexity, high usability, cross-platform, quality)

2

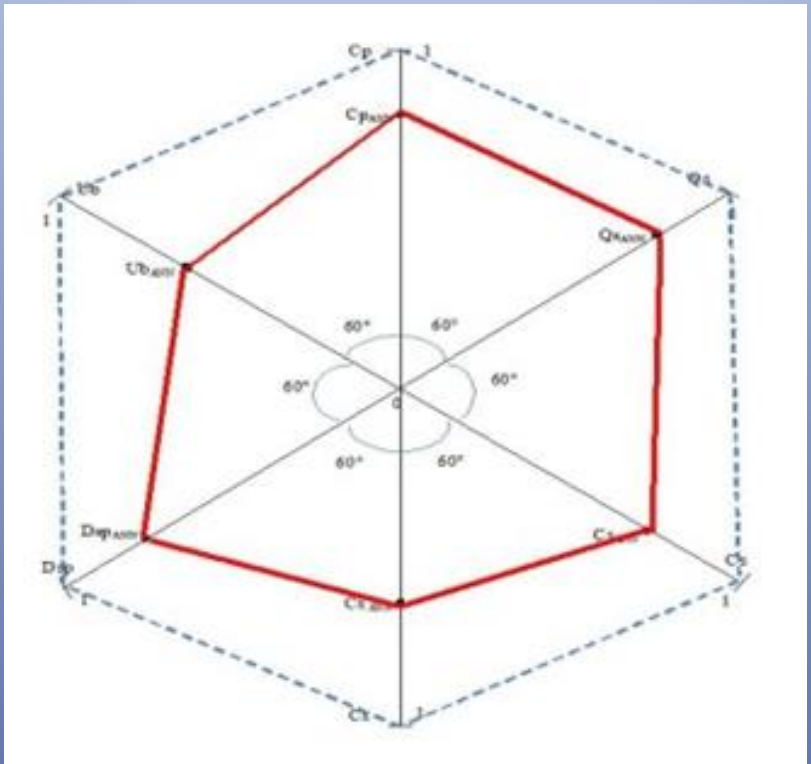
- Interpretation of the received relative values of the software project characteristics – criteria for this interpretation is the **integrative indicator of software project**:
- **Iip_{Sp}=0.5*0.866*(Cs*Cx+Cx*Dsp+ Dsp*Ub+ Ub*Cp+Cp*Qs+ Qs*Cs)**

3

- Evaluation of the degree of success of the software project implementation on the basis of the integrative indicator:
- **$P_{Iip}=Iip_{Sp}/Iip_{max}=Iip_{Sp}/2.598=0.385*Iip_{Sp}$**

4

- Testing of the stability and acceptability of compensations of software project characteristics: the indicator Ace_{Sp} of stability and acceptability of compensatory effects of the characteristics has the value “True”, if the hexagon is convex (if the sum of the angles of hexagon is 720° and sines of angles have the same signs)

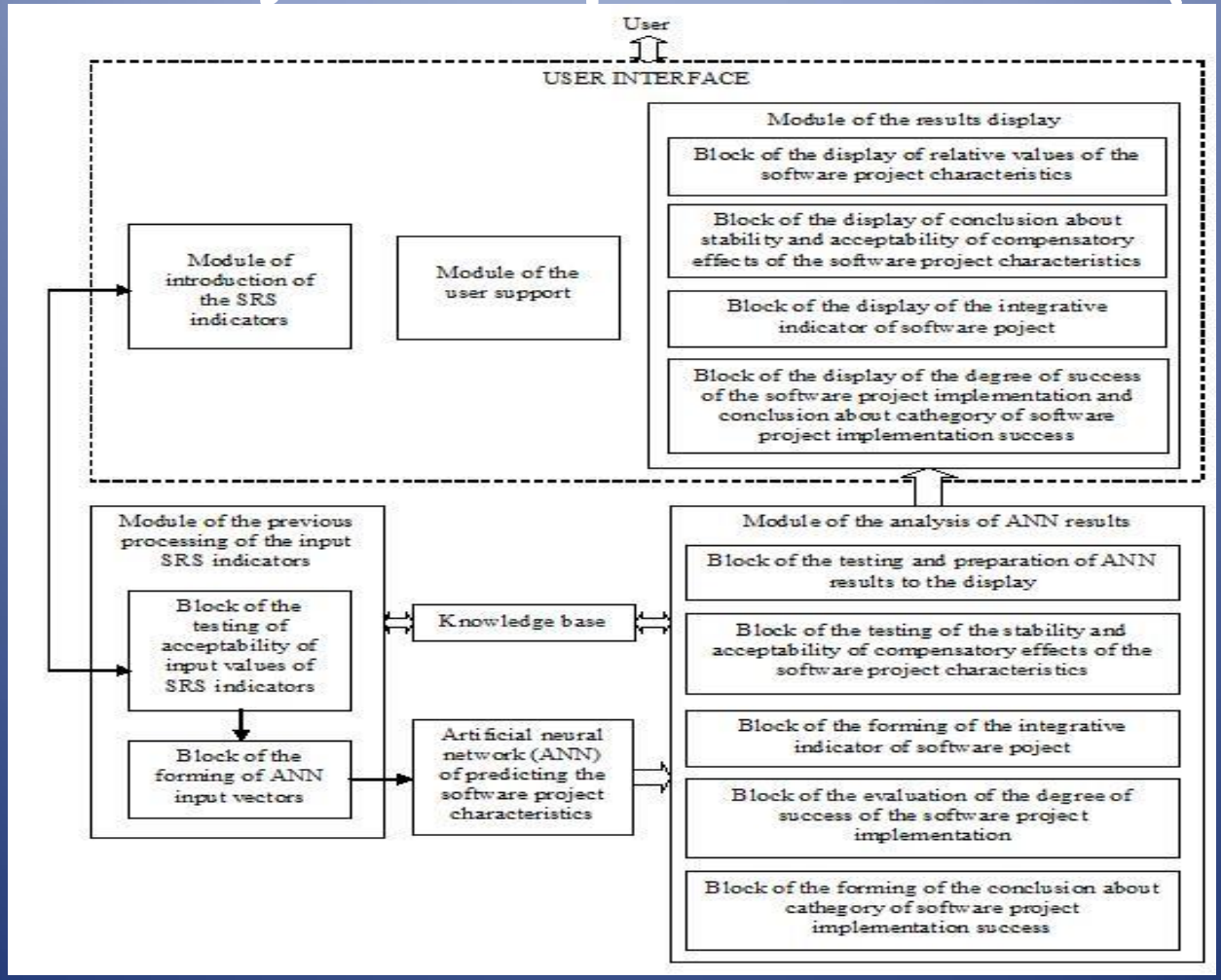


The graphical representation of lip_{Sp} and lip_{max}

The input data for MESSPI: the set **R1-R3** of SRS indicators

The result of MESSPI: **evaluation of the degree of success of the software project implementation,** which provides to perform the reasonable choice of SRS for the further implementation of the project.

Intelligent System of Predicting the Characteristics and Evaluating the Success of Software Projects Implementation (SPCES)



The structure chart of structure (algorithmic-focused vision with elements of architectural solutions) of SPCES

The input data for SPCES: the selected 24 SRS indicators.

The result of SPCES:

- the relative values of the software project characteristics
- the conclusion about stability and acceptability of compensatory effects of the software project characteristics, the integrative indicator of software project (graphical representation and value)
- the value of the degree of success of the software project implementation
- the conclusion about category of success of software project implementation (the successful, the challenged or the failed project is expected)

The rules for the testing of acceptability of input values of SRS indicators (are substantiated by the valid ranges of the SRS indicators values, that were defined based on the analysis of the above-described 410 SRS):

1. if Tv € [1..24] (months), then flag=true, else flag=false;
2. if Qv € [1..10] (persons), then flag=true, else flag=false;
3. if Sa € [1..1000] (persons), then flag=true, else flag=false;
4. if Qcs € [1..50] (components), then flag=true, else flag=false;
5. if Sc € [50..50000] (lines of code), then flag=true, else flag=false;
6. if Cos € [0..1250] (USD), then flag=true, else flag=false;
7. if Cdb € [0..1250] (USD), then flag=true, else flag=false;
8. if Cc € [0..1250] (USD), then flag=true, else flag=false;
9. if Cdt € [0..1250] (USD), then flag=true, else flag=false;
10. if Cud € [1..50] (pages), then flag=true, else flag=false;
11. if Sud € [50..2500] (USD), then flag=true, else flag=false;
12. if Qfr € [5..300] (requirements), then flag=true, else flag=false;
13. if Cfr € [50..4750] (USD), then flag=true, else flag=false;
14. if Qa € [1..500] (algorithms), then flag=true, else flag=false;
15. if Cb € [10..960] (USD), then flag=true, else flag=false;
16. if Cui € [50..3000] (USD), then flag=true, else flag=false;
17. if Qmi € [50..2450] (interfaces), then flag=true, else flag=false;
18. if Cmi € [25..2500] (USD), then flag=true, else flag=false;
19. if Qai € [5..100] (interfaces), then flag=true, else flag=false;
20. if Cai € [25..1500] (USD), then flag=true, else flag=false;
21. if Qci € [5..125] (interfaces), then flag=true, else flag=false;
22. if Cci € [25..1750] (USD), then flag=true, else flag=false;
23. if Qnfr € [1..9] (requirements), then flag=true, else flag=false;
24. if Cnfr € [50..4000] (USD), then flag=true, else flag=false;
25. if flag=true, then the input values of the SRS indicators are acceptable, else if flag=false the input values of the SRS indicators are not acceptable, in this case the method MESSPI and the system SPCES cannot be used for this SRS and project.

The rules for the testing of acceptability of input values of SRS indicators (are substantiated by the quantities of the elements of the above-described sets R1-R3):

1. on the input x'_i (i=1..5) the value of i-th element of set R1 of the indicators of the section 1 of the SRS is submitted;
2. on the input x''_k (k=1..6) the value of k-th element of set R2 of the indicators of the section 2 of the SRS is submitted;
3. on the input x_j (j=1..13) the value of j-th element of set R3 of the indicators of the section 3 of the SRS is submitted;
4. if the user doesn't enter the value of indicator, then corresponding input of ANN is -1.

The rules for the testing and preparation of ANN results to the display (are substantiated by the above-described approach to ANN training):

1. if Cs=0 or Dsp=0 or Cx=0 or Cp=0 or Ub=0 or Qs=0, then insufficient data for prediction of the software project characteristics, in this case the method MESSPI and the system SPCES cannot be used for this SRS and project;
2. output y_1 - Cs – the relative value of the software project cost, output y_2 – Dsp – the relative value of the software project duration, output y_3 - Cx – the relative value of the software project complexity, output y_4 – Ub – the relative value of the software project usability, output y_5 – Cp – the relative value of the software project cross-platform, output y_6 – Qs – the relative value of the software project quality.

The rules for the testing of the stability and acceptability of compensatory effects of the software project characteristics (are substantiated by the above-described method MESSPI)

1. if the hexagon is convex (if the sum of the angles of hexagon is 720° and sines of angles have the same signs), then the indicator $Aces_{Sp}$ of stability and acceptability of compensatory effects of the characteristics has the value "True";
2. if the hexagon isn't convex (if the sum of the angles of hexagon isn't 720° or sines of angles have the different signs), then the indicator $Aces_{Sp}$ of stability and acceptability of compensatory effects of the characteristics has the value "False";
3. if $Aces_{Sp}$=True, then the chararcteristics are stable, the compensations of characteristics are acceptable, the method MESSPI and the system SPCES are suitable for this software project and this SRS, else if $Aces_{Sp}$=False, then the chararcteristics are unstable, the compensations of characteristics are unacceptable, the method MESSPI and the system SPCES are not suitable for this software project and this SRS.

The thresholds values of the degree of success of the software project implementation for different types of software projects:

	Web-applications	Mobile applications	E-learning	Applications for statistics, accounting	Automated systems	Information systems
Failed software projects	$P_{Iip} \leq 0.17$	$P_{Iip} \leq 0.19$	$P_{Iip} \leq 0.15$	$P_{Iip} \leq 0.16$	$P_{Iip} \leq 0.17$	$P_{Iip} \leq 0.18$
Challenged software projects	$0.17 < P_{Iip} \leq 0.62$	$0.19 < P_{Iip} \leq 0.60$	$0.15 < P_{Iip} \leq 0.61$	$0.16 < P_{Iip} \leq 0.62$	$0.17 < P_{Iip} \leq 0.61$	$0.18 < P_{Iip} \leq 0.59$
Successful software projects	$P_{Iip} > 0.62$	$P_{Iip} > 0.60$	$P_{Iip} > 0.61$	$P_{Iip} > 0.62$	$P_{Iip} > 0.61$	$P_{Iip} > 0.59$

The rules for the forming of the conclusion about category of success of the software project implementation (considering the empirical estimates from top Table, which in general correspond to the statistical evaluations):

1. if the value of the degree of success of the software project implementation $P_{Iip} \leq 0.19$, then software project is predictably failed;
2. if the value of the degree of success of the software project implementation $0.19 < P_{Iip} \leq 0.62$, then software project is predictably challenged;
3. if the value of the degree of success of the software project implementation $P_{Iip} > 0.62$, then software project is predictably successful.

Experiments with SPCES

The input data for the SPCES: the SRS indicators for 5 software projects, that were developed by the different groups of developers for the solution of the one task – the development of the automated system for large-format photo print – to the order by LLC «Deymos», Khmelnitsky.

№ pr.	The set of indicators of section1 of SRS	The set of indicators of section2 of SRS	The set of indicators of section3 of SRS	
1	Tv=6, Qv=3, Sa=220, Qcs=13, Sc=10900	Cos=260, Cdb=324, Cc=216, Cdt=270, Cud=11, Sud=690	Qfr=83, Cfr=1075, Qa=108, Cb=216, Cui=705, Qmi=680, Cmi=563,	Qai=29, Cai=415, Qci=30, Cci=400, Qnfr=3, Cnfr=910
2	Tv=13, Qv=6, Sa=495, Qcs=25, Sc=26090	Cos=624, Cdb=640, Cc=648, Cdt=639, Cud=25, Sud=1329	Qfr=160, Cfr=2510, Qa=258, Cb=505, Cui=1687, Qmi=1310, Cmi=1315,	Qai=53, Cai=805, Qci=65, Cci=925, Qnfr=5, Cnfr=2110
3	Tv=18, Qv=8, Sa=770, Qcs=37, Sc=36940	Cos=249, Cdb=300, Cc=219, Cdt=283, Cud=10, Sud=650	Qfr=149, Cfr=2530, Qa=247, Cb=499, Cui=1683, Qmi=1302, Cmi=1319,	Qai=52, Cai=811, Qci=67, Cci=918, Qnfr=5, Cnfr=2100
4	Tv=24, Qv=10, Sa=1000, Qcs=50, Sc=50000	Cos=0, Cdb – not defined, Cc – not defined, Cdt – not defined, Cud – not defined, Sud – not defined	Qfr=300, Cfr=4750, Qa=500, Cb=960, Cui=3000, Qmi=2450, Cmi=2500,	Qai=53, Cai=805, Qci=65, Cci=925, Qnfr=5, Cnfr=2110
5	Tv – not defined, Qv=1, Sa – not defined, Qcs – not defined, Sc – not defined	Cos=620, Cdb=641, Cc=645, Cdt=653, Cud=27, Sud=1326	Qfr=167, Cfr=2498, Qa=262, Cb=509, Cui=1691, Qmi=1313, Cmi=1310,	Qai=56, Cai=798, Qci=62, Cci=929, Qnfr=5, Cnfr=2125

ANN input and output vectors for five software projects:

№ pr.	Input 1 (x')	Input 2 (x'')	Input 3 (x)	Output (Y)
1	[6;3;220;13; 10900]	[260;324;216; 270;11;690]	[83;1075;108; 216;705;680; 563;29;415;30; 400;3;910]	[0.789;0.782; 0.792;0.79; 0.795;0.792]
2	[13;6;495;25; 26090]	[624;640;648; 639;25;1329]	[160;2510;258; 505;1687;1310; 1315;53;805;65;925;5 ;2110]	[0.518;0.521; 0.521;0.53; 0.53;0.518]
3	[18;8;770;37;36940]	[249;300;219; 283;10;650]	[149;2530;247; 499;1683;1302; 1319;52;811;67;918;5 ;2100]	[0.539;0.537; 0.542;0.533; 0.54;0.542]
4	[24;10;1000;50; 50000]	[0;-1;-1;-1;-1;-1]	[300;4750;500; 960;3000;2450; 2500;53;805;65;925;5 ;2110]	[0.389;0.082; 0.39; 0.097; 0.093;0.389]
5	[-1;1;-1;-1;-1]	[624;648;648; 648;25;1329]	[167;2498;262; 509;1691;1313; 1310;56;798;62;929;5 ;2125]	[0.68;0.522; 0.681;0.52; 0.52;0.68]

The values of the indicator Ace_{Sp} of stability and acceptability of compensatory effects of the characteristics, integrative indicator Iip_{Sp}, the degree of success P_{Iip} of the software project implementation and the conclusion about category of software project implementation success for five above software projects:

№ pr.	Ace_{Sp}	Iip_{Sp}	P_{Iip}	Conclusion about category of software project implementation success
1	True	1,621	0,624	Successful project
2	True	0,711	0,274	Challenged project
3	True	0.754	0.290	Challenged project
4	False	-	-	The software projects characteristics are unstable, the compensations of characteristics are unacceptable, so this system is not suitable for this project and for this SRS
5	True	0.942	0.363	Challenged project

Predicted (in the SRS) values of cost and duration for the four software projects:

Characteristics of software project	Values for Project №1	Values for Project №2	Values for Project №3	Values for Project №5
Predicted cost, specified in the SRS	11875 USD	11125 USD	10625 USD	10812 USD
Predicted duration, specified in the SRS	6 months	13 months	18 months	Not defined

The values of the characteristics of software projects show, that all four software projects have the different duration but the same cost that predicted in the SRS. But the results of SPCES show, that projects have significantly different relative values of all characteristics, including the cost, which were calculated taking into account all significant SRS indicators. In addition, Table shows that the examined software projects have the different category of software project implementation success. Therefore, the values of main characteristics, provided by ANN and the conclusions of SPCES about the category of software project implementation success will help **to make the right choice and to implement the software project which will be successful with the greatest probability (among from four examined software projects is Project №1**).

Conclusions

- The structure of **information technology of predicting the characteristics and evaluating the success of software projects implementation** (ITPCES) is first time proposed. The basic components of ITPCES are the previously developed by the author the neuronet model of predicting the software projects characteristics and the method of evaluating the success of software projects implementation based on analysis of SRS and also (yet not developed) the intelligent system of predicting the characteristics and evaluating the success of software projects implementation
- The structure of the **intelligent system of predicting the characteristics and evaluating the success of software projects implementation** (SPCES) are proposed. This system **gives the conclusion about the probably category of success of the software project implementation based on analysis of the SRS** (at the early stages of the life cycle).
- The **practical significance of the proposed information technology** ITPCES is this fact, that system's conclusions about the category of the success of software project implementation provide to the customers the comparison of the proposed software projects and the data for the reasoned and informed choice of the most successful software project (not just on the basis of the project cost and duration, as is currently).

THANK YOU FOR ATTENTION!

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