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Research Article

Autoanalysis, a Program Package for Laboratory Automation and Process Analysis

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Abstract

The appearance of microprocessors and computers represented a significant leap in the automation of analytical methods. They have gradually been integrated into analytical instrumentation, especially in data acquisition and treatment. However, given chemists' general lack of experience in connecting computers to instrumentation, the widespread use of automation has been evolving very slowly. The development of informatics and the increase in power of computers have been facilitating and giving flexibility to automation, allowing the development of systems according to the needs of the different analytical methods.

The appearance of various commercial programs has facilitated the design of automatic systems according to the analytical needs. However, still very few programs allow designing automatic systems based on flow techniques in a versatile way.

This paper aims to review the software package called AutoAnalysis, which facilitates the combination of many devices and instruments according to the needs of the different analytical methods. Although it was initially intended for automation based on flow techniques, such as the FIA, SIA, MSFIA, LOV, etc., it has also demonstrated its effectiveness in other fields, like its application to chromatographic techniques, capillary electrophoresis, etc. This program is not only useful for laboratory work, but it can also be used to monitor industrial processes, such as the operation control of a bioreactor.

To describe the high possibilities of AutoAnalysis, we have decided to do its description in several papers:

1. AutoAnalysis: Introduction and background. This paper describes the software design, how it should be used by different users without interfering with each other, and how to configure the system to connect with the various instruments and devices of the system being developed. A table is included describing how the program has been used over the years, from 1999 to 2026.

2. AutoAnalysis: Programming. Once an automated system has been configured for a new application, this paper describes how to program the system, how to save the methods, and how to retrieve applications described in previous papers.

It describes how to define procedures, define variables, design calibration systems, create loops to analyze different samples after repeating the procedure several times for each one, and how to execute the developed methods.

Thus, it describes how to establish criteria for discriminating noise from analytical signals, how to obtain the derived curves using the Savitsky-Golay technique, how to obtain and save the spectra for each experimental point, and how to manage the calibration systems.

3. AutoAnalysis: Methods and data can be organized in Works. By organizing methods, data, and configuration in Works, these can be related, and it is a way of organizing different projects to facilitate the organization of the user. AutoAnalysis form designer allows developing autonomous methods that can be used without the need to have AutoAnalysis installed

This paper includes an appendix describing various devices that can be used in the application of automated methods controlled by the AutoAnalysis program.

More Information

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Keywords: Automation; Flow analysis; Software package

Abbreviations: AAS: Atomic Absorption Spectroscopy; AFS: Atomic Fluorescence Spectroscopy; Amper: Amperometry; ASV: Anodic Stripping Voltammetry; CE: Capillary Electrophoresis; Chemi: Chemiluminescence; Conduct: Conductometry; DLL: Dynamic Link Library; FIA: Flow Injection Analysis; Fluor: Fluorimetry; GC-ECD: Gas Chromatography with Electron Capture Detector; GC-FID: Gas Chromatography with Flame Ionization Detector; GC-MS: Gas Chromatography-Mass Spectrometry; HPLC: High Performance Liquid Chromatography; LBPC: Low Background Proportional Counter; ICP-AES: Inductively coupled plasma atomic emission spectroscopy; ICP-OES: Inductively coupled plasma optical emission spectroscopy; LIS: Lab-in-Syringe; LOV: Lab on Valve; MCFIA: multicommuted Flow Injection Analysis; MLIS: Magnetic Lab-in-Syringe; MOF: Metal Organic Framework; MPFS: Multipumping Flow System; MSC: Multisyringe Chromatography; MSFIA: Multisyringe Flow Injection Analysis; Pot: potentiometry; SIA: Sequential Injection Analysis; SIC: Sequential Injection Chromatography; Spec: spectrophotometry; LSC: Liquid scintillation counting; Voltam: Voltammetry

Introduction

One of the main limitations found in the automation of analysis techniques has been that of having the appropriate programs to control the different components of the system while simultaneously acquiring and processing the data. This has been one of the causes of the slow initial development of some of the flow techniques, especially those that require the use of computers, such as sequential injection analysis, multi-syringe flow injection analysis, lab-on-valve, etc. [1].

Initially, the control programs were carried out in a very restrictive way using MSDOS operative system and BASIC or equivalent language [2], very inflexible since the software had to be adapted for each application. The appearance of QBASIC facilitated the use of programming, but the programs continued to be inflexible in that they had to continue to be modified depending on the application to be developed, even after facilitating their use with the introduction of libraries. A new advance was achieved with the appearance of visual programs, such as Visual Basic, higher-level languages (Delphi, C++, etc.). With the appearance of these new languages and with the experience gained in the development of software applied to the automation of flow techniques, it was then that the development of the AutoAnalysis program began [3].

AutoAnalysis is a software that affords high flexibility in automating analytical methods (Table 1). Thus, with an appropriate choice of instrumental modules and the required dynamic link libraries (DLLs), AutoAnalysis allows the automatic or semi-automatic implementation of a host of flow techniques, including Flow Injection Analysis (FIA), Sequential Injection Analysis (SIA), Multi-Commuted Flow Injection Analysis (MCFIA), Multi Pumping Flow System (MPFS), Multi-Syringe Flow Injection Analysis (MSFIA), Lab-on-Valve (LOV), Lab in Syringe (LIS), Magnetic Lab in Syringe (MLIS), Capillary Electrophoresis (CE) and HPLC. Combined with these flow techniques, a lot of different kinds of detectors may be used, like UV spectrophotometry, Vis spectrophotometry, fluorimetry, atomic absorption spectrometry, atomic fluorescence spectrometry, ICP-AES, ICP-MS, potentiometry, voltammetry, conductometry, etc.

Although it was primarily conceived for flow techniques, AutoAnalysis also affords the automation of other laboratory processes such as maintaining the pH of a medium by addition of appropriate amounts of an acid or base (pHStat) or controlling bioreactors. In fact, this software provides a wide range of analytical solutions only limited by the user's instrumentation. AutoAnalysis has also been used as a low-cost software for different chromatographies and capillary electrophoresis [4,5].

One of the greatest advantages of AutoAnalysis is that it allows a variety of problems to be solved using a single software suite, thereby avoiding the need to learn and use a different program for each instrument, providing an open environment. Since AutoAnalysis has been developed for the Win32 platform, it can be run simultaneously with other programs such as word processors, spreadsheets, or Internet browsers.

AutoAnalysis accepts conditional variables and commands; in fact, it has its own programming language, which facilitates the development of intelligent routines. Thus, AutoAnalysis can make a decision by itself based on the analytical results gathered at a given point without intervention of the analyst [6]. This paper will provide a more detailed description of its use for people interested in using it.

Table 1 provides readers and users with numerous detailed examples of how to use the program in a wide range of analytical applications. Specifically, it details numerous applications using various instrumental techniques: spectrophotometric, fluorometric, thermometric, voltammetric, and flow techniques, among others.

Software philosophy

AutoAnalysis consists of a main application and a set of DLLs (Dynamic Link Libraries) that facilitate connection to various types of instruments and their control. The distinctive feature of this software, based on 32-bit DLLs, is the possibility of using a single and versatile application without further modification for whatever instrumentation and detection system is needed. It involves a basic protocol which allows the implementation of specific and individual DLLs, addressing the configuration of the assembled flow analyzer. Thus, being a very flexible tool, easy to handle by non-specialized users.

The main application is independent of hardware configuration. That means the same main application is used for any configuration of connected instruments and measuring devices with the same user interface, options, and facilities.

Instruments are connected to a communication channel (a DLL) that is managed by the software in a user-transparent manner. A single channel can be shared by several instruments at once, each being governed by a specific DLL.

The software automatically manages individual registered user accounts, which include personal configurations, preferred methods, output data, etc. This facilitates a management system for each user, separating its methods and data files from those of other users. With this differentiation of system and user control, AutoAnalysis just loads the necessary program code to work with specific instrumentation, thereby saving system resources (RAM, hard disk).

AutoAnalysis was designed to consist of three layers, namely, application (layer 1), instruments and communication channels (layer 2), and hardware (layer 3) (Figure 1).

Table 1: Papers related to the use of the AutoAnalysis software.

Period	first Author	Subject	flow techniques	Detection system	Reference
1999	E.Becerra	Design of AutoAnalysis		Software	Lab. Robotics & Automation, 11 (1999) 131-140
	V.Cerdà	Devices controlled with AutoAnalysis		General	Talanta, 50 (1999) 695-705
	F.Albertús	Single point titration of protolytes	SIA, MSFIA	Spec	Analyst, 124 (1999) 1373-1381
2000	G. de Armas	Mg with 8-hydroxiquinoline-5-sulfonic acid	SIA	Fluor	Talanta 52 (2000) 77–82
	N.V. Semenova	Total inorganic As	SIA	AFS	Analytica Chimica Acta, 412 (2000) 169-175
	M. Miró	Nitrites with solid phase extraction	SIA	spec	Analyst, 125 (2000) 943–948
	M.A.Segundo	SO_2 in wines	MSFIA	spec	Analyst, 2000, 125, 1501–1505
	F.Albertús	free acidity and iron(III)	MSFIA	spec	Analyst, 2000, 125, 2364–2371
2001	J.A.Erustes	IODIDE BY CATALYTIC	SIA	spec	J. AOAC, 84 (2001) 337-341
	G. de Armas	Fuberidazole	SIA	Fluor	Analytica Chimica Acta 427 (2001) 83–92
	M. Miró	Nitrophenols	MSFIA	spec	Analytica Chimica Acta 438 (2001) 103–116
	V.Cerdà	Environmental parameters	SIA, MSFIA, FIA	Spec, AFS, AAS, Pot,	Trends in Analytical Chemistry, 20 (2001) 407-418
	F.Albertús	nickel(II) and iron speciation	MSFIA	Spec	Analyst, 2001, 126, 903–910
	M.Miró	Nitrites reflectance optrode	FIA	Spec	Analyst, 126 (2001) 1740-1746
	J.A.Erustes	Nitrites reflectance optrode	SIA	Spec	Analyst, 261 (2001) 451-456
2002	G. de Armas	Al, Time based	MSFIA	Fluor	Analytica Chimica Acta, 455 (2002) 149-157
	A.Andrade	Cl	SIA, MSFIA	Pot	Analytica Chimica Acta, 467 (2002) 25-33
	G. de Armas	Al	SIA	Fluor	Química Analítica, 20 (2002) 211-215
	G. de Armas	Warfarin with SPE	MSFIA	Fluor	Analytica Chimica Acta, 467 (2002) 13-23
	N.V. Semenova	Total inorganic As	MSFIA	AFS	Analytica Chimica Acta, 455 (2002) 277-285
	M. Miró	^{90}Sr	SIA	LBPC	Analytical Chemistry, 74 (2002) 826-833
	M. Miró	MSFIA review	MSFIA	Spec	Trends in Analytical Chemistry, 21 (2002) 199-210
	N. Pizá	Co MSFIA	MSFIA	Chemi	Analytica Chimica Acta, 467 (2002) 155-166
	C. Brach-Papa	Al	SIA	Fluor	Analytica Chimica Acta, 457 (2002) 311-318
	G. de Armas	Fluorophores	SIA	Fluor	Analytica Chimica Acta, 471 (2002) 173-186
	G. de Armas	Multiresidue	SIA	Fluor	Luminescence, 17 (2002) 259-260
	N. Pizá	Sugar	MSFIA	Chemi	Luminescence, 17 (2002) 205-206
2003	M. Oms	Total N	SIA	Spec	Talanta, 59 (2003) 319-326
	J.J. Mateos	^{226}Ra and ^{90}Sr semiautomatic	SIA	LBPC	Int.J.Env.Anal.Chem., 83 (2003) 515-521
	J. Klimundova	Ammonium	MSFIA	Spec	Int.J.Env.Anal.Chem., 83 (2003) 233-246
	P. Rumori	Cu with cuprizone	FIA, SIA	Spec	Analytica Chimica Acta, 476 (2003) 227
	N.V. Semenova	Totl inorganic Se	MSFIA	AFS	Analytica Chimica Acta, 486 (2003) 217
	V.Cerdà	MSFIA review	MSFIA		J.Flow Anal., 20 (2003) 203-206
2004	F. Mas	orthophosphate	SIA	Spec	Analytica Chimica Acta, 510 (2004) 61-68
	C. Pons	Fe(II) and Fe(III)	MCFIA	Spec	Talanta, 62 (2004) 887-895
	I.P.A. Morais	orthophosphate	MSFIA	Chemi	Analytica Chimica Acta, 506 (2004) 17-24
	N. Pizá	Automated enzymatic assays	MSFIA	Chemi	Analytical Chemistry, 76 (2004) 773-780
	M. Manera	Glucose	MSFIA	Chemi	Analytica Chimica Acta, 508 (2004) 23-30
	L.O. Leal	Inorganic As	MSFIA	AFS	Talanta, 64 (2004) 1335-1342
	C. Pons	Speciation of iron using chelating disk	MSFIA	Spec	Analytica Chimica Acta, 524 (2004) 79-88
	G. de Armas	Sulfide	MSFIA	Spec	Analytica Chimica Acta, 524 (2004) 89-96
	L. Ferrer	Sulfide	MSFIA	Spec	Talanta, 64 (2004) 1119-1126
	Y. Fajardo	Stable and radioactive Sr	MSFIA	Spec, AAS	Applied Radiation and Isotopes, 61 (2004) 273-277
2005	N.V. Semenova	Sb speciation	MSFIA	AFS	Analytica Chimica Acta, 530 (2005) 113-1
	C. Pons	Fe speciacion	MSFIA	Spec	Analytica Chimica Acta, 528 (2005) 197-203
	M. Miró	MSFIA review chemiluminescence	MSFIA	Chemi	Analytica Chimica Acta, 541 (2005) 57-68
	J.M. Estela	Phosphorus flow techniques		review	Talanta, 66 (2005) 307-331
	V.Cerdà	Automatic pre-concentration and treatment	FIA; SIA; MSFIA; MCFIA; MPFS	Review	Int.J.Env.Anal.Chem, 85 (2005) 231-253
	C. Pons	Fe speciation using anion. exchange disks	MSFIA	Spec	Talanta, 66 (2005) 210-217
	Y. Fajardo	Stable and Radioactive Yttrium	MSFIA	LBPC	Analytica Chimica Acta, 539 (2005) 189-194
	L. Ferrer	Sulfide solid-phase reflectometry	MSFIA	Spec	Talanta, 68 (2005) 343-350
	L. Ferrer	Optrode	MSFIA	Spec	Talanta, 68 (2005) 343-350
	C. Pons	Speciation of iron	MPFS	Spec	Analytica Chimica Acta, 550 (2005) 33-39
	B. Horstkotte	Automation using MSFIA	MSFIA	Review	J. Flow Analysis, 22 (2005) 99-109
2006	J.L. Guzman	1-naphtylamine with optrode	MSFIA	Spec	Analytica Chimica Acta, 573-574 (2006) 406-412
	V.Cerdà	Multicommutated flow techniques	MCFIA	Review	Trends in Anal. Chem., 25 (2006) 236-242
	B. Horstkotte	Formaldehyde in bioprocess	FIA, SIA, HPLC	Spec	Analytica Chimica Acta, 559 (2006) 248-256
	L.O. Leal	Inorganic As	MSFIA	AFS	Talanta, 69 (2006) 500-508
	J.L. Guzman	1- naphtylamine optical fiber reflectance	MSFIA	Spec	Analytica Chimica Acta, 573-574 (2006) 406-412

	L. Ferrer	Sulfide	MSFIA	Spec	Analytica Chimica Acta, 573-574 (2006) 391-398
	C. Pons	Iron	MCFIA	review	Trends in Analytical Chemistry, 25 (2006) 583-588
	L.O. Leal	Hg cold vapor	MSFIA	AAS	Analytica Chimica Acta, 573-574 (2006) 399-405
	J.B. Quintana	HPLC	MSFIA-LOV	Spec	Analytical Chemistry, 78 (2006) 2832-2840
	C. Pons	orthophosphate	MPFS	Spec	Analytica Chimica Acta, 572 (2006) 148-154
	X. Long	Hydride-forming element	MSFIA-LOV	AFS	Analytical Chemistry, 78 (2006) 8290-8298.
	L.M.Magalhaes	Hypochlorous acid scavenging activity	MSFIA	Chemi	Luminiscence, 20 (2006) 370-371
	Y. Fajardo	Flow techniques for radioactive isotopes	SIA, MSFIA	review	Proceedings IV Jornadas sobre Calidad en el Control de la Radiactividad Ambiental. (2006) 97-106
2007	L. Ferrer	Flow techniques for sulfide	FIA, SIA,MSFIA	review	Trends in Analytical Chemistry, 26(5) (2007) 413-422.
	M. Manera	Nitrophenols with optrode	MSFIA	Spec	Analytica Chimica Acta, 582 (2007) 155-163
	Y. Fajardo	^{230}Ra	MSFIA-MPFS	LBPC	Talanta, 71 (2007) 1172-1179
	H.M. González	amoxicillin, ampicillin and cephalexin	MSC	Spec	Talanta, 72 (2007) 296-300
	B. Horstkotte	Glycerol	SIA	Spec	Talanta, 71 (2007) 941-947
	M. Manera	Nitro-substituted phenols	MSFIA	Spec	Analytica Chimica Acta, 582 (2007) 41-49
	J. Buanuam	orthophosphate	MSFIA	Spec	Talanta, 71 (2007) 1710-1719
	H.M. González	β-lactamic antibiotics	MSC	Spec	Analytical and Bioanalytical Chemistry, 387 (2007) 663-671
	B. Horstkotte	Electrophoresis nitrophenols	SIA	Spec	Int. J. Environ. Anal. Chem. 87 (2007) 797-811
	V.Cerdà	Review flow techniques	MSFIA, SIA, MPFS, MSC	Spec, Pot, chem	Analytica Chimica Acta, 600 (2007) 35-45
	L.M. Magalhaes	Hypochlorous Acid Scavenging	MSFIA	Chemi	Analytical Chemistry, 79 (2007) 3933-3939
	F. Maya	Sulphide	MSFIA	Chemi	Analytica Chimica Acta, 601 (2007) 87-94
	V. Gómez	Phenols	MSC	Spec	Analytical Chemistry, 79 (2007) 7767-7774
2008	C. Pons	Nitrite and nitrate	MPFS	Spec	Microchimica Acta, 161 (2008) 73-79
	Y. Fajardo	^{241}Am and $^{239+240}$Pu	MSFIA-MPFS	LBPC	Analytical Chemistry, 80 (2008) 195-202
	A. Serra	Hg cold vapour	MSFIA	AFS	Talanta, 77 (2008) 556–560
	M.A. Obando	hydrochlorothiazide and losartan potassium	MSC	Spec	Analytical and Bioanalytical Chemistry, 161 (2008) 73-79
	F. Maya	Cl	MSFIA	Spec	Talanta, 74 (2008) 1534-1538
	M. Fernández	B6, B1, and B12 vitamins	MSC	Spec	Analytical and Bioanalytical Chemistry, 391 (2008) 817-825.
	M.A. Obando	hydrochlorothiazide and losartan potassium	MSC	Spec	J. Pharmaceutical and Biomedical Analysis, 48 (2008) 212–217
	B. Horstkotte	MSFIA capillary electrophoresis	MSFIA	Spec	Talanta, 76 (2008) 72 - 79
	N. Ornelas	hypochlorite	MSFIA	Spec	Analytica Chimica Acta, 611 (2008) 182-186
	F. Maya	Halogenated organic compounds	MSFIA	Spec	Analytical Chemistry, 80 (2008) 5799–5805
	B. Horstkotte	Sorbitol	SIA	Spec	Biochemical Engineering Journal, 42 (2008) 77-83
	M. Rosende	Municipal solid waste incineration bottom ashes	SIA	ICP-AES	Analytica Chimica Acta, 619 (2008) 192-201.
	O. Elsholz	Acetat- Konduktometrische Untersuchungen	FIA, MSFIA	Conduct	GIT Labor-Fachzeitschrift 2 (2008) 110-113
	W. Boonjob	Fractionation of Trace Elements in Fly Ash	MSFIA	ICP-AES	Analytical Chemistry, 80 (2008) 7319-7326
2009	H.M. González	Review	MSC	Spec	Trends in Analytical Chemistry, 28 (2009) 336-346
	J.L. Guzman	Uranium	MSFIA	Spec	J Radioanal Nucl Chem (2009) 281:433–439
	H.M. Oliveira	Phenolic pollutants	MSFIA-HPLC	Spec	Talanta, 77 (2009) 1466-1472
	F. Maya	Cl	MSFIA	Spec	Analytical and Bioanalytical Chemistry, 394 (2009) 1577-1583
	N. Ornelas	azinphos methyl	MSFIA	Spec	Microchimica Acta. 167 (2009) 273-280
	F. Maya	Green spectroscopy	MSFIA	Spec	Spectroscopy Letters, 42 (2009) 312-319
	A.M. Serra	Hg speciation	MSFIA	AFS	Talanta 78 (2009) 790–794
	M. Manera	Gabapentin	MPFS	Chemi	Luminescence, 24 (2009) 10-14
	F.M. Bauzá	Energy cogeneration system	MSFIA-SIA	Spec, Conduc	Talanta, 79 (2009) 1011-1020
	M. Rosende	Dynamic fraction of trace metals	SIA	ICP-AES	Talanta, 79 (2009) 1081-1088
	W. Boonjob	automatic sequential BCR extraction	SIA	ICP-OES	Analytical and Bioanalytical Chemistry, 394 (2009) 337
	B. Horstkotte	Flow Techniques with Capillary Electrophoresis	MSFIA	Review	Journal of Chromatographic Science, 47 (2009) 636-647
	J.B. Quintana	Polychlorinated Biphenyls	LOV-GC	ECD	Analytical Chemistry, 81 (2009) 4822-4830
2010	B. Horstkotte	Winkler-based dissolved oxygen in seawater	MSFIA	Spec	Talanta, 80 (2010)1341-1346
	J.L. Guzman	Tinidazol	MSFIA	Spec	J. Chilean Chemical Society, 55 (2010) 215-218
	B. Horstkotte	Winkler	SIA	Spec	Analytica Chimica Acta, 658 (2010) 147-155.
	H.M. Oliveira	UV filters	MSFIA-LOV	Spec	Journal of Chromatography A, 1217 (2010) 3575-3582
	M. Rosende	automatic dynamic extraction	SIA	ICP-OES	Analytica Chimica Acta, 658 (2010) 41-48
	H.M. Oliveira	Riboflavin in foodstuffs	LOV-HPLC	Spec	Analytical and Bioanalytical Chemistry, 397 (2010) 77-86
	J. Avivar	Uranium using a liquid waveguide capillary cell	MSFIA	Spec	Analytical and Bioanalytical Chemistry, 397 (2010) 871-878

	F. Maya	Thiazide diuretics	MSC	Chemi	Talanta, 80 (2010) 1333-1340
	A.M. Serra	Selenium	MSFIA	Spec	Talanta, 81 (2010) 572-577
	B. Horstkotte	Solenoid-Pump Flow Systems	MPFS		Analytical Chemistry, 82 (2010) 6983-6990
	C. Fernández	Sulphonated azo dyes	MSC	Spec	Talanta, 82 (2010) 137-142
	Y. Delgado	plaguicidas organofosforados	MSFIA	GC-MS	Ciencia, 18 (2010) 280-291
	F. Maya	organic compounds expressed as total indices	flow techniques	review	Talanta 81 (2010) 1–8
	Y. Fajardo	Automation of radiochemical analysis	Flow techniques	review	Trends in Analytical Chemistry, 29 (2010)1399-1408
	A. Anthemidis	Hg	LOV	AFS	Journal of Analytical Atomic Spectrometry, 25 (2010) 1717-1723.
	B. Horstkotte	Capillary electrophoresis	MSFIA	Spec	Global Journal of Analytical Chemistry, 1 (2010) 262-274
	W. Boonjob	Herbicides	MSFIA-LOV-HPLC	Spec	Analytical Chemistry, 82 (2010) 3052-3060
	R. Brunetto	cocaine and benzoylecgonine in urine	MSFIA	GC-MS	Journal of Separation Science, 33 (2010) 1779-1786
	L. Chaparro	As organic	MSFIA	AFS	Proceedings CIPITECH 2010
	A. Ayala	Nitrite, nitrate and sulfate	SIA	Spec	Proceedings CIPITECH 2010
	J. Avivar	Uranium	MSFIA, LOV, MPFS	Spec	Proceedings Control de la Radioactividad Ambiental
2011	A.R.T.S. Araujo	Phenolic compounds	MSFIA	Chemi	Luminescence, 26 (2011) 571–578
	S.M. Oliveira	Bromate	MSFIA	Spec	Analytical Letters, 44 (2011) 284-297
	M.I.G.S. Almeida	MSFIA hyphenation with separation techniques	MSFIA- MSC, HPLC, GC, CE	Spec, GC-ECD, CE	Analytical Letters, 44 (2011) 360-373
	M.I.G.S. Almeida	Ammonium	MSFIA	Spec	Talanta, 84 (2011) 1244–1252
	J. Avivar	Uranium	MSFIA-LOV	Spec	Talanta, 84 (2011) 1221–1227
	F. Maya	Oxalate	MSC	Chemi	Microchimica Acta, 173 (2011) 33-41
	M. Pokrzywnicka	Ascorbic	SIA	Spec	Analytical and Bioanalytical Chemistry, 399 (2011) 1381-1387
	E. Björklund	anticoccidial agents	SIC	Spec	Microchemical Journal, 98 (2011) 190–199
	L.O. Leal	As	MSFIA, LOV	AFS	Trends in Analytical Chemistry, 30 (2011) 761-770
	J.L. Guzman	Thorium	MSFIA	Spec	Journal of Radioanalytical and Nuclear Chemistry, 289 (2011) 67-73
	F. Maya	paraquad	MSFIA	Spec	Talanta, 85 (2011) 588-595
	J. Avivar	Th and U	LOV	Spec	Anal Bioanal Chem., 400 (2011) 3585–3594
	B. Horstkotte	Ammonium	MPFS	Fluor	Talanta 85 (2011) 380-385
	R. Suárez	RuBisCo	MSFIA	Spec	Talanta, 84 (2011) 1259–1266
	M. Rosende	Cr(VI)	MSFIA	Spec	Analytical and Bioanalytical Chemistry, 400 (2011) 2217-2227
	W. Boonjob	Priority environmental pollutants	MSFIA-HPLC	Spec	Analytical Chemistry, 83 (2011) 5237-5244
	J.L. Guzman	Hg speciation	MSC	AFS	Analytica Chimica Acta, 708 (2011) 11– 18
2012	J. Avivar	Thorium and Uranium	MSFIA-LOV	ICP-MS	Journal of Analytical Atomic Spectrometry, 27 (2012) 327-334
	F. Maya	benzo(a)pyrene	LIS-MSC	Spec	Analytical and Bioanalytical Chemistry 40 (2012) 1383–1388
	A. Ayala	sulfate, nitrite and nitrate	SIA	Spec	Microchemical Journal 100 (2012) 55–60
	M. Fernández	A review of SIC and MSC	SIC, MSC	Spec	Instrumentation Science & Technology, 40 (2012) 90-99
	S.M. Oliveira	Bromate with optosensor	MSFIA	Spec	Analytical Methods, 4 (2012) 1229-1236
	B. Horstkotte	Nitrites	MPFS	Spec	Int. J. Envir. Anal. Chem., 92(2012) 344-354
	C. Henríquez	Cd	MSFIA	ASV	Talanta 96 (2012) 140– 146
	R. Rodríguez	Total Sr and ^{90}Sr	LOV	LBPC, ICP-OES	Talanta, 96 (2012) 96-101
	D. Cocovi	Glucose biosensing film	LOV	Spec	Talanta, 96 (2012) 113-120
	L.L. Chaparro	dimethylarsinic and total inorganic arsenic	MSFIA	AFS	Analytical and Bioanalytical Chemistry, 404 (2012) 1589-1595
	W.L. Castilleja	Cr(VI) with optode	MSFIA	Spec	Talanta, 99 (2012) 730–736
	B. Horstkotte	Cu	LIS	Spec	Talanta, 99(2012) 349-356
	F. Maya	Lab in a syringe	LIS	Spec	Analytical and Bioanalytical Chemistry, 404 (2012) 909-917
	C.A. Chavez	dicamba, 2,4-D, and atrazine	MSC	Spec	Analytical and Bioanalytical Chemistry, 403 (2012), 2705-2714
	M.P. Cañizares	Norepinephrine, Epinephrine and Dopamine	MSC	Spec	J. Mex. Chem. Soc., 56 (2012) 194-200
	B. Horstkotte	Phenol index	LIS	Spec	Microchimica Acta, 179 (2012) 91-98
	A.M. Serra	Selenium speciation	MSFIA	AFS	Journal of Analytical Atomic Spectrometry, 27 (2012) 1858–1862
	R. Suárez	Al	LIS	Fluor	Analytical Chemistry. 84 (21) (2012) 9462-9469
	M. Fernández	Water-soluble vitamins	MSC	Spec	Analytical Letters, 45 (2012) 2637-2647
	V. Cerdà	Kinetics	MSFIA	Spec	J. Braz. Chem. Soc., 23 (2012) 1989-1996
2013	C. Henríquez	Ammonium	MSFIA	Conduct	Int. J. Envir. Anal. Chem, 93 (2013) 1236-1252
	D.G. Silva	Hg	MSFIA	AFS	Food Chemistry 137 (2013) 159–163

	F.Z. Abouhiat	Iodide	MSFIA in chip	Spec	Talanta, 108 (2013) 92-102
	B. Horstkotte	Nitrite and nitrate	MSFIA chip-on-valve	Spec	Analytical Letters, 46 (2013) 2345-2358
	B. Horstkotte	magnetic LIS	MLIS	Fluor	Analytica Chimica Acta, 788 (2013) 52-60
	C. Henríquez	Cr(VI)	MLIS	Spec	Analytical and Bioanalytical Chemistry, 405 (2013) 6761-6769
	M. Villar	^{99}Tc	LOV	LSC	Analytical Chemistry, 85 (2013) 5491-5498
	C. Chávez	degradation of 2,4-D and dicamba	MSFIA	Spec	Journal of Environmental Management, 129 (2013) 377-383
	B. Beltrán	Lead and strontium isotopic analysis	LOV	ICP-MS	Environmental Science & Technology: 47 (2013) 9850-9857
	J. Guzman	Hg speciation	MSC	AFS	Química Hoy, 3 (2013)
2014	B. Horstkotte	LIS and MLIS	LIS, MLIS	Spec	Trends in Analytical Chemistry 59 (2014) 1–8
	C. Henríquez	total inorganic carbon and ammonium	MPFS	Conduct	Talanta, 118 (2014)186-194
	P. Phansi	Mo katalytic in-chip	MSFIA in chip	Spec	Talanta, 119 (2014) 68–74
	J. Avivar	Radionuclids	LOV	Spec, ICP-MS	VII Jornadas control de la radiactividad ambiental, (2014) 358-367
	M. Mola	Separación de ^{90}Sr y ^{210}Pb	LOV	LSC	VII Jornadas control de la radiactividad ambiental, (2014) 347-358
	M. Mola	90Sr and 210Pb	LOV	LSC	Applied Radiation and Isotopes, 86 (2014) 28-35
	S. Clavijo	Six phthalates	LIS	GC-MS	Journal of Separation Science, 37 (2014) 974-981
	S. Clavijo	Sixteen priority PAHs	LIS	GC-MS	Analytical Methods, 6 (2014) 3335-3344
	P. Phansi	Mn katalitic in-chip	MSFIA in chip	Spec	Analytical Methods, 6 (2014) 5088-5096
	F. Maya	LIS review	LIS, MLIS	Spec	TrAC Trends in Analytical Chemistry, 59 (2014) 1-8
	B. Horstkotte	Cationic surfactants	MLIS	Spec	Analytical Methods, 6 (2014) 9601 - 9609
	R. Suárez	Methylene blue active substances assay	MLIS	Spec	Talanta, 130 (2014) 555-560
	P. Phansi	Cu catalytic in-chip	MSFIA in chip	Spec	Analytical Methods, 6 (2014) 8494 - 8504
	F.Z. Abouhiat	Vanadium catalytic in-chip	MSFIA in chip	Spec	Analytical Methods, 6 (2014) 9142 - 9151
	L. Silva	Cd cold vapour	MSFIA	AFS	Journal of Analytical Atomic Spectrometry, 29 (2014) 2398 - 2404
	R. Rodríguez	^{99}Tc	LOV	ICP-MS	VIII Jornadas de control de la radioactividad ambiental. 2014
2015	R. Rodríguez	^{99}Tc	LOV	ICP-MS	Talanta, 133 (2015) 88-93
	L. Chaparro	Co-catalytic in-chip	MSFIA	Spec	Talanta, 133 (2015) 94-99.
	M.R. Brunetto	atenolol and propranolol	MSFIA	GC-MS	Talanta, 132 (2015) 15-22
	S. Clavijo	Hyphenation with Flow Injection Techniques	SIA, MSFIA, MSC	HPLC, GC-MS, CE	TrAC Trends in Analytical Chemistry, 67 (2015) 26–33
	R. Rodríguez	Uranium	MLIS	SPEC	Talanta, 134 (2015) 674-680
	A. Gozález	priority phenolic pollutants	MLIS	MSC	Analytical and Bioanalytical Chemistry, 407 (2015) 2013–2022
	M. Fernández	polycyclic aromatic hydrocarbons	LIS	HPLC Fluor	Talanta, 138 (2015) 190–195
	L. Portugal	Sb speciation	MSFIA	AFS	Journal of Analytical Atomic Spectrometry, 30 (2015) 1133
	J.M. Rosas	As	MSFIA	AFS	Analytica Chimica Acta, 874 (2015) 1-10
	M. Rodas	Parabens	MSC	Chemi	Talanta, 143 (2015) 254–262
	K. Danchana	Bromide	MSFIA	Spec	Analytical Methods, 7 (2015) 4202-4208
	B. Beltrán	Lead	LOV	AFS	Journal of Analytical Atomic Spectrometry, 30 (2015) 1072-1079
	M. Villar	^{99}Tc	LIS	LSC	Analytical and Bioanalytical Chemistry, 407 (2015) 5571–5578
	F. Maya	Malachite green	MLIS MOF	Spec	Analytical Chemistry, 87 (2015) 7545-7549
	V. Cerdà	Review MCFIA, MSFIA, MPFS	MCFIA, MSFIA, MPFS	Review	Flow Injection Analysis. CRC Press, 2015
	F.Z. Abouhiat	Fe and Cu, catalytic in-chip	SIA	Spec	Analytical Methods, 7 (2015) 7858-7865
	R.M. Frizzarin	Iodide	MSFIA in chip	Fluor	Talanta, 144 (2015) 1155-1162
	A. Gozález	Estrogens	MLIS	GC	Journal of Chromatography A, 1413 (2015) 1-8
2016	R.M. Frizzarin	Sb	LIS	Spec	Talanta,148 (2016) 694-699
	L. Chaparro	Mn catalytic in-chip	LOV	Spec	Talanta, 148 (2016) 583-588
	R. Rodríguez	LIS in radiochemical analysis	LIS, MLIS	ICP-MS, ICP-OES, LBPC	Trends in Analytical Chemistry 76 (2016) 145–152
	C.R. Silva	Comparison of MSFIA and MPFS	MSFIA, MPFS	Conduct	Talanta, 148 (2016) 596-601
	R. Suárez	UV filters	MLIS	HPLC Spec	Talanta, 148 (2016) 589–595
	R. Rodríguez	^{226}Ra	LOV	LBPC	Analytica Chimica Acta, 911 (2016) 75-81
	J.M. Rosas	As	MSFIA	AFS	Food Chemistry, 204 (2016) 475-482
	S. Clavijo	UV filters	MLIS	GC-MS	Journal of Chromatography A, 1443 (2016) 26-34
	M. Ghani	MSFIA stir bar	MSFIA	HPLC	Journal of Chromatography A, 1445 (2016) 10–18
	C. Calderilla	Bi	MSFIA	Spec	IJEAC, 96 (2016) 653-666.
	F. Santana	Antimony, arsenic and selenium	MSFIA	ASV	Talanta, 156-157 (2016) 29-33
	R.M. Frizzarin	Cafeine	MLIS	Spec	Food Chemistry, 212 (2016) 759-767

	R.M. Frizzarin	anionic surfactants	SIA	Spec	Analytical Chem, 88 (2016) 6990-6995
	M. Ghani	organic pollutants	SIA	HPLC	RSC Advances, 6 (2016) 48558-48565
	C. Henríquez	In chip catalytic review	MSFIA, MFFS		Trends in Analytical Chemistry, 85 (2016) 33–45
	M. Rodas	^{226}Ra	LOV	α Proporcional counter	IX Jornadas en el control de la reactividad ambiental
	V. Cerdà	Environmental monitoring flow techniques	SIA, MSFIA, MCFIA, MPFS, LIS LOV	review	Environmental Monitoring- Studium Press 2016
	J.M. Rosas	As	MSFIA	AFS	Toxicology Letters 259S (2016) S73–S247
2017	F.Z. Abouhiat	Co-catalytic in-chip	MSFIA	Spec	Talanta, 166 (2017) 405-411
	A. Gozález	estrogens	MLIS	GC-MS	Analytical and Bioanalytical Chemistry, 409 (2017) 225-234
	M. Silva	Sb(V), Sb(III), thrimethyl antimony(v) and total antimony	MSFIA	AFS	Talanta, 165 (2017) 502-507
	A. Cervantes	Cd	LOV	ICP-MS	Microchemical Journal, 132 (2017) 107-111
	M. Ghani	Phenols	SIA	HPLC	J.Chromatography A, 1488 (2017) 1-9
	V. Cerdà	Kinetic catalytic methods. Review	MSFIA, MPFS		Talanta, 167 (2017) 733-746
	M. Rodas	^{226}Ra dynamic lixiviation	LOV	LBPC	Talanta, 167 (2017) 398-403
	F. Maya	MOFs review PAH	LIS MOF	HPLC UV	Trends in Analytical Chemistry, 90 (2017) 142-152
	M. Villar	^{99}Tc	LOV	LSC	Analytical Chemistry, 89 (2017) 5857-5863
	C. Calderilla	Iron speciation	LOV	Spec	Talanta, 175 (2017) 463-469
	M. Rodas	U and Th	LOV	ICP-MS	Talanta,175 (2017) 507-513
	R. Rodríguez	U	MLIS	Spec	Proceedings congreso de Química E Ingeniería Verde, 2017, 10-15
	R. Rodríguez	Cd	LOV	ICP-MS	Proceedings congreso de Química E Ingeniería Verde, 2017, 16-21
	J.O.Pozo	Radionuclides Sr-90/Y-90, Am-241	LOV	LSC	LSC (2017) 148
2018	F. Maya	Emerging materials for sample preparation	SIA	GC-MS, HPLC	J. Separation Science, 41 (2018) 262-287
	V. Cerdà	MSFIA in spectroanalytical techniques, review	MSFIA, LOV, MPFS, MSC, CE	Spec, Fluor, Chemi, ICP-OES, ICP-MS, AFS	Trends in Analytical Chemistry, 98 (2018) 1-18
	R. Suárez	Herbicides	MLIS	GC-MS	Journal of Separation Science, 41 (2018) 1096-1103
	M. Ghani	phenolic acids	SIA	HPLC	Journal of Separation Science, 41 (2018) 2012-2019.
	C. Calderilla	Cr(VI)	MSFIA	Spec	Talanta (ICFIA), 184 (2018) 15–22
	P. Phansi	Hyphenation of flow-spectrometric techniques	SIA, MSFIA, MPFS, LOV, LIS	ICP-AES, ICP-OES, AFS, AAS	Applied Spectroscopy Reviews, 53 (2018) 854-876
	G. Chango	Simultaneous F, Cl, pH, and redox potential	MPFS	Pot	Talanta (ICFIA), 186 (2018) 554-560
	D.V. Medina	dispersive liquid-liquid microextraction parabens	SIA	HPLC	Talanta, 189 (2018) 241–248
	C. Calderilla	Recent advances in solid-phase extraction	SIA, MSFIA	Spec, HPLC	Trends in Analytical Chemistry, 108 (2018) 370e380
	D.A. Vargas	Solidification of the Organic Phase	SIA	HPLC	Talanta 189 (2018) 241-248
2019	K. Danchana	sulfur dioxide	MPFS	Conduct	Analytical Letters, 52 (2019) 1363-1378
	P. Phansi	Iron	MSFIA	Spec	Food Chemistry, 277 (2019) 261-266
	A. Gozález	Estrogens	LOV	GC	Talanta, 194 (2019) 852-858
	S. Ferreira	Speciation analysis of antimony	MSFIA	AFS	Trends in Analytical Chemistry
	M. Rodas	Uranium	MLIS	ICP-MS	Talanta, 202 (2019) 267-273
	V. Cerdà	Automation of radiochemical analysis	REVIEW		Trends in Analytical Chemistry, 118 (2019) 352-367
	M.S. Sammani	Flavonoids in citrus juices	LOV	HPLC	Analytica Chimica Acta, 1082 (2019) 56-65
	D. Esparza	^{131}I	LOV	LSC	Talanta, 206 (2019) 120224
	K. Danchana	Uranium (IV)	MSFIA	Spec	Microchemical Journal, 150 (2019) 104148
2020	A. Gozález	Estrogens	LOV	HPLC	Talanta, 209 (2020) 120564.
	R. Rodríguez	Lead	MLIS	Spec	Microchemical Journal, 154 (2020) 104550
	C. Henríquez	Cd screen printed	MSFIA	Voltam	Electroanalysis, 32 (2020) 1323-1328
	C. Andreu	Total iron in wines	MPFS	Spec	Analytical Letters, 53 (2020) 2775-2783
	D.V.L. Avila	As and Sb	MSFIA	AFS	Analytical Methods, 12 (2020) 2621-2630
	H.M.Gozález	Vitamin E	MSC	Spec	Analytical Letters, 53 (2020) 2949-2959
	D. Barzallo	Quinine	MSFIA	Fluor	Talanta, 218 (2020) 121163
	P. Jitthiang	Benzoic and sorbic acids	MSFIA	HPLC	Current Topics in Analytical Chemistry, 12 (2020) 43 - 51
	V. Cerdà	Continuous-Flow Extraction	Review		Handbooks in Separation Science
2021	M.A. Vargas	Volatile fatty acids	MLIS	GC-FID	Journal of Chromatography A, 1643 (2021) 462034
	M.A. Vargas	Long-chain fatty acids	MLIS	GC-MS	Anal Bioanal Chem, 413 (2021) 3833-3845
	M.S. Sammani	Flavonoids in citrus flavedo	MLIS	HPLC	Microchemical Journal, 168 (2021) 106421
2022	S.O. Souza	Se inorganic speciation	MSFIA	AFS	Food Chemistry, 367 (2022) 130673
	V. Cerdà	MCFIA, MSFIA, MPFS Review	review		CRCPress
	M.S. Sammani	quality control of foods and pharmaceuticals	review		The Book of Flavonoids
	J.L.A. Miranda	Iodine	MSFIA-chip	Fluor	Molecules, 27 (2022) 1325

	S. Ferreira	State of the art for selenium speciation	review		Trends in Analytical Chemistry, 152 (2022) 116617
	L. Portugal	Sb speciation	MSFIA	ICP-MS	Chemosensors, 10 (2022) 139
	E.A. Zagatto	Lead	LIS	Spec	Talanta, 247 (2022) 123528
	P. Phansi	Equilibrium constants		Pot	Trends in Analytical Chemistry, 155 (2022) 116676
	V. Cerdà	Detection pollutants	LIS, MLIS, MCS	HPLC, GC-MS	Molecules, 27 (2022) 7279
	V. Cerdà	Protonation constants		Amper	Current Topics in Analytical Chemistry, 14 (2022) 25-36
	V. Cerdà	flow-through cells	MSFIA	Amper, Voltam	Progress in Chemical and Biochemical Research, 5 (2022) 351-366
2023	L. Portugal	Inorganic selenium speciation	MSFIA	AFS	Talanta, 252 (2023) 123897
	S. Ferreira	isotopic analysis of uranium and thorium	MSFIA, SIA, LOV, MLIS	Spec, ICP-MS	Trends in Analytical Chemistry, 166 (2023) 117146.
2024	R. Rodríguez	Isotopic analysis of strontium and yttrium	SIA, MSFIA, LOV, MSFIA-LOV-ICP-MS	Proportional counter, ICP-MS	Talanta 270 (2024) 125643
2025	D. Avila	Co, Cu, Mn, As, Cd, Cr, Sb, Ni and Pb in toys	MSFIA	ICP-OES, AFS	Journal of Trace Elements and Minerals Volume 12, June 2025, 100226

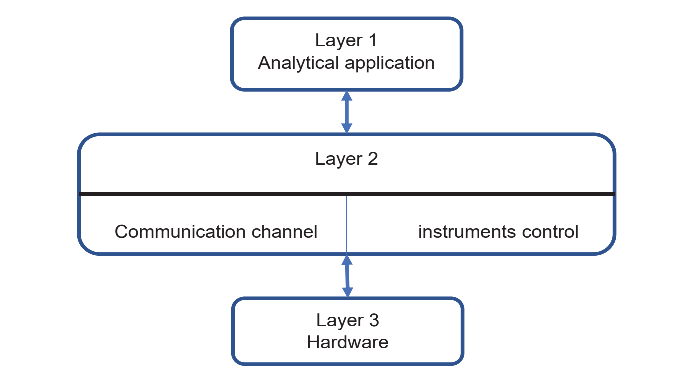

Figure 1: Layers configuration of the AutoAnalysis software package.

The application layer was developed on the Microsoft Windows platform (Win32), and the intermediate layer was implemented as dynamic link libraries (DLLs); moreover, a communication interface between it and the main application was defined.

- The bottom layer (layer 3) consists of the devices that are connected directly to the computer, interface cards and device drivers, manufacturer libraries for the control of the equipment, and programming the connection interfaces.
- The middle layer (layer 2) consists of communication channels and tools, i.e., it is subdivided into two parts. However, there are not two sub-layers, since each part is directly connected to the upper and lower layer. Communication channels are defined to provide the application with enough information about the actual scheme of hardware connections.
- The middle layer (layer 2) prevents the application (layer 1) from communicating directly with the hardware (layer 3). This is one of the objectives of layer 2: achieving independence of the hardware configurations from the application layer.
- Finally, there is the analytical application layer of concern. It includes the connected hardware configurations, methods, and data acquisition and processing, being the final user interface.

To work with the AutoAnalysis application, there is the following sequence of steps:

- Configuring the connected hardware: the user chooses the equipment and connections to be used and selects the most appropriate settings for the channels and instruments that are to come into play.
- Designing the analytical method to be used with the connected hardware: the programming tools of the software are used to develop the most appropriate method via the sequence of operations and decisions to reach expected results.
- Executing method to realize expected commands and data capture: It executes commands previously programmed with related instrumentation. When measuring instruments are started, corresponding data is acquired.
- Data processing: mathematical treatment of the previously acquired data such as curve smoothing (e.g. with the Savitzky-Golay algorithm), derivation, calibration or spectral refining. Data can also be exported to be processed with other software (e.g. Excel spreadsheet).

Starting with autoanalysis

The installation procedure is divided into two main stages, that is to say, the installation of the main application and that of the instruments and channels Dynamic Link Libraries (DLLs).

The basic requirements of AutoAnalysis are: operating system Windows95/98/2000/NT/XP/Win7/Win10, Pentium, 512 MB RAM memory (better 1GB). 100 MB free hard disk (HD) space, a screen resolution of 800x600, and Internet Explorer 5.0 or superior.

The environment of the program is customized for each user, e.g., saving hardware configurations, methods, and data. Thus, a user must be selected before starting to use the program. A list of all registered users appears when opening the program (Figure 2). First, select your username and type your password.

For a new user, the program will ask for the data to create their account, for example: Full name, Password, and Password confirmation. Once a user has been created, so has its workspace. Thus, the program automatically creates a workspace in the installation directory, in the subdirectory *Users,* where there is another subdirectory for each user. If

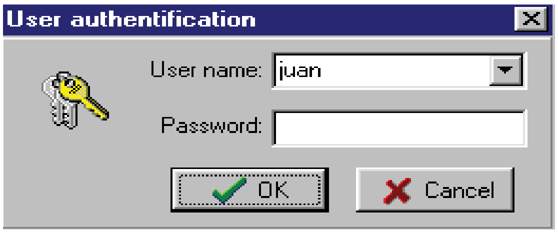

Figure 2: User authentication window.

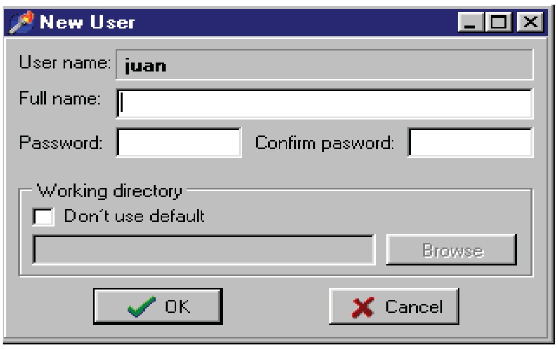

Figure 3: New user creation window.

another directory is desired, select *Don't use default* (Figure 3) and indicate the desired working directory. The button *Browse* can be used to find the desired directory. It is advisable not to change the working directory.

Main window

AutoAnalysis main window has a column with an option bar (Figure 4). All functions of the software can be reached by clicking on the desired button.

Available options are:

- *About*: it shows information about the software.
- *User*: user edition tool (Name, password, workspace, ...)
- *Works*: this section can be used to organize configurations, methods, and data.

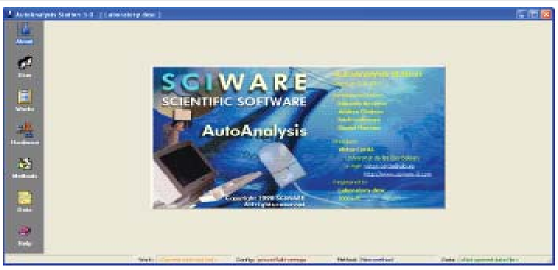

Figure 4: AutoAnalysis main.

- *Hardware*: connected *Hardware* configuration tool.
- *Methods*: methods edition and execution tool.
- *Data*: data processing tool.
- *Help*: online help function.

Each section functionality will be explained in detail below.

In the status bar, the configuration name, the metThe method, and the loaded data file appear.

Hardware configuration

The Hardware option is very flexible since it allows the settings for the body of equipment components connected to the computer to be loaded, saved, deleted, or changed at any time (Figure 5). In fact, the Configuration menu only displays the DLLs for the communication channels and instruments employed by the users in their particular applications. The software will only load into memory the DLLs explicitly selected by the user for a specific purpose, avoiding the computer's memory overload.

When configuring the system, it is very useful to use a detailed block diagram for the process, including the channels to be used to connect the analytical equipment to the computer. First, the communication channels required are loaded. Then the instruments needed are implemented. Finally, the instruments concerned are linked with the communication channels present in the Configuration tree.

On the left appear the *Available configurations* previously saved by the user. These can be selected, and the following operations can be carried out:

- *Load*: load the selected configuration
- *Delete*: delete the selected configuration
- Filter by *Work*

When a configuration is selected, the name of the file where it is saved appears on thOn the right of the Delete button.

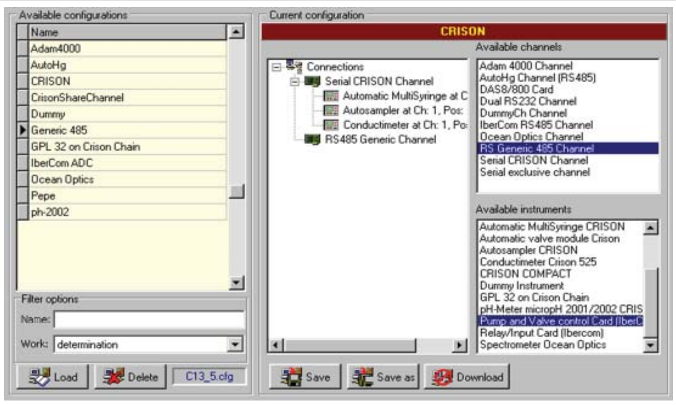

Figure 5: Hardware window.

https://doi.org/10.29328/journal.jairi.1001023

On the right side appears the *Current configuration,* which can be modified. This section is divided into three panels; on the left there is the tree where the channels and instruments linked to each channel appear; on the right side, at the top are displayed the list of *Available channels*, and at the bottom are displayed the *Available instruments*.

Available actions:

- Add new channels to the configuration: select the channel from the list of Available channels and drag it over Connections on the tree view.
- Link new instruments to a channel: select the channel from the list of Available instruments and drag it over the desired channel.
- Channels and instruments configuration, delete channels and disconnect instruments: select the channel or instrument you want to configure or delete and press the right button of the mouse; a menu will appear with the following options:
    - *Delete channel*: it deletes the channel. It is only possible to delete a channe• Without linked instruments.
    - *Configure channel*: it allows channel configuration.
    - *Disconnect instrument*: disconnect instruments from the channel.
    - *Configure instrument*: it allows instrument configuration.
    - *Help*: online help.
    - *Save*: save current configuration.
    - *Save as*: save current configuration with another name. When saving an existing configuration with another name or a new one, the window shown in Figure 6 appears, and the configuration is associated with the current Work.
    - *Download*: Download current configuration from memory.

Example of a configuration of a SIA system with spectrophotometric detection

Figure 5.3 shows the AutoAnalysis configuration for an SIA system with spectrophotometric detection. The branches of the tree in the "current configuration" panel include a Crison serial communication channel and an Ocean Optics USB communication channel. Once the required communication channels are chosen, their operational settings (communication rate, word length, number of stop bits, control parity) can be selected in terms of the instruments to be employed. For some

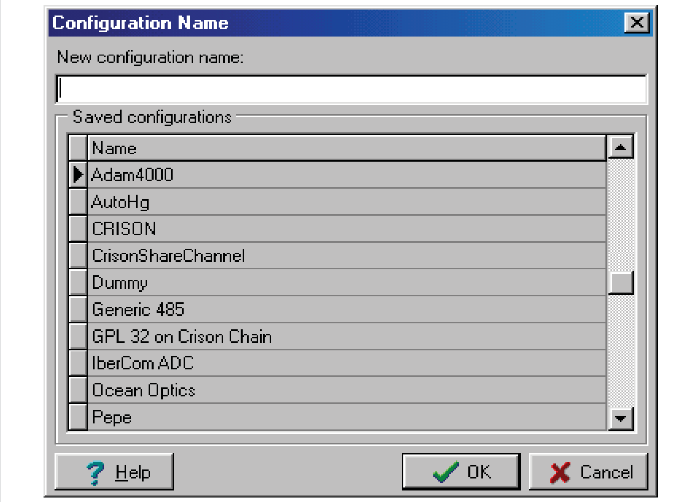

Figure 6: New configuration name window.

instruments, these settings are predDefined and cannot be modified.

Once all channels have been selected and configured, the miniaturized Ocean Optics CCD spectrophotometer is linked to its communication channel, and so are the Crison valve module and burette to theirs, e.g., first the valve (position 0) and then the burette (position 1). After these elements are strung, they can be individually configured, and operational characteristics such as the type of valve used (e.g., one selection valve and one injection valve), number of ports, syringe volumes, and burette steps can be selected.

Step-by-step description:

Select the required instrumentation: e.g. a multisyringe burette, a CRISON selection valve and an Ocean Optics spectrophotometer.

Connect and configure the channels: the two channels required are shown in Figure 7.

Connect and configure the instruments: Figure 8 shows the final configuration.

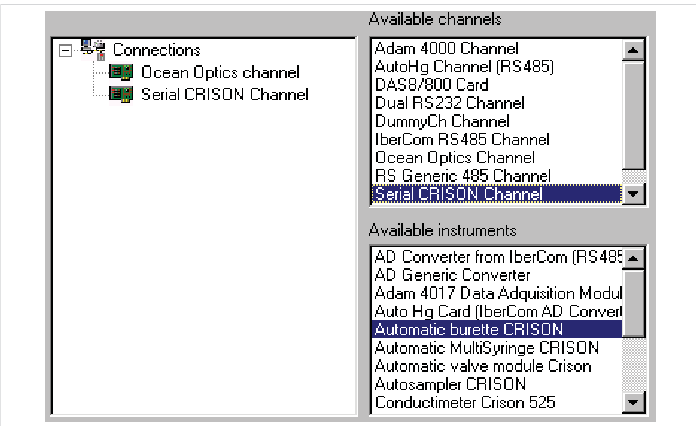

Figure 7: Configuration creation: Channel connection.

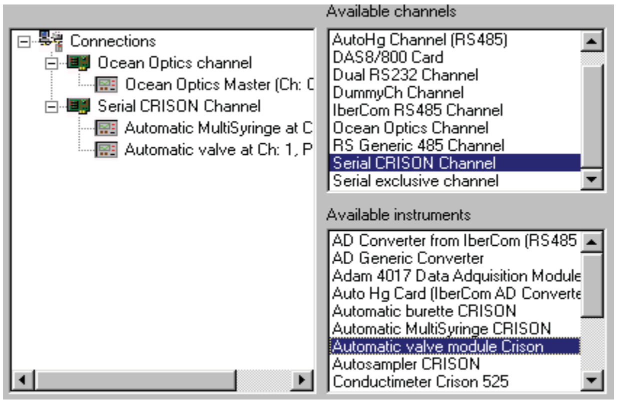

Figure 8: Configuration creation: Instruments connection.

Conclusion

AutoAnalysis is a very versatile software that allows combining different instruments and applying flow techniques in a very easy way. This means that in the same laboratory different researchers may use the same program applying different techniques. Once an analyst has learned how to use AutoAnalysis in a defined application, he will be able to use the same program for other applications in a very easy way. AutoAnalysis is useful not only for laboratory, but also for process analysis.

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