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Interdisciplinary

Multi-Dimensional Rajan Transform

Source of Sexual and Reproductive

Highlights

Study of Social Entrepreneurship

Smart Lock using Image Recognition

Discovering Thoughts, Inventing Future

VOLUME 20 ISSUE 6 VERSION 1.0

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The Internet as a Reliable Source of Sexual and Reproductive Health Information among Rural School-Aged Children in Oaxaca, Mexico

By Claudia Díaz-Olavarrieta, Beatriz Cruz-Cruz, Germán E. Fajardo-Dolci, Antonio R. Villa., Monica Aburto-Arciniega, Ma. Isabel Salazar-Gomez, Sandra García-Medina, Citlali González-Álvarez, Vivian J. Phillips, Vania Contreras-Sánchez, Rosalinda Guevara-Guzmán & Luis M. Sánchez-Navarro

University of Mexico

Abstract- *Background:* Correct and culturally relevant sexual and reproductive health knowledge among children and adolescents is a key component to a healthy life. In Mexico, a country plagued with a teen pregnancy epidemic, sexuality education in the public-school system begins in 4th grade. Our study aims were to characterize the sexual and reproductive health knowledge of middle school students from Oaxaca, and its association with belonging to an indigenous group, gender, sources of sexual and reproductive health information, and parents' level of schooling.

Methods: Cross-sectional study. Students responded to a multiple-choice paper and pencil self-administered survey on sexual and reproductive health knowledge. Our sample included 245 middle-school students (51.4% were female) enrolled in rural school's 7th, 8th, and 9th grade. Survey contents were based on the Ministry of Education textbooks.

Keywords: *sexual and reproductive health; oaxaca; mexico; enrolled school children, the internet.*

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The Internet as a Reliable Source of Sexual and Reproductive Health Information among Rural School-Aged Children in Oaxaca, Mexico

Claudia Díaz-Olavarrieta [α], Beatriz Cruz-Cruz [σ], Germán E. Fajardo-Dolci [ρ], Antonio R. Villa. [ω], Monica Aburto-Arciniega [¥], Ma. Isabel Salazar-Gomez [§], Sandra García-Medina [χ], Citlali González-Álvarez [ν], Vivian J. Phillips [Θ], Vania Contreras-Sánchez [ζ], Rosalinda Guevara-Guzmán [£] & Luis M. Sánchez-Navarro [€]

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Results: Failing scores in individual sections and diagrams were associated with gender and self-identifying as belonging to an indigenous group. Students obtained higher scores in the knowledge-based technical sections vs diagrams. Students self-identifying as indigenous had a two-fold risk of failing the visual recognition of contraceptive methods (OR 2.38 [CI 95% 1.05-5.42]). Using the internet as a source of reference for this section was a protective factor (OR 0.33 [CI 95% 0.12-0.89).

Conclusion: Sexual and reproductive health information is best learned using new technologies such as the Internet, even among disadvantaged populations such as adolescents attending rural schools in Oaxaca. Sexuality education needs to be taught in a continuum especially in contexts where unintended pregnancy is high and the need for adequate information on contraceptive methods so pressing.

Keywords: sexual and reproductive health; oaxaca; mexico; enrolled school children, the internet.

I. Background

In 2018, Mexico hosted over 22 million adolescents[1] with a fertility rate of 70.6.[2] In 2014, the latter was calculated at 77, representing live births and no record of pregnancies ending in abortion.[3]The country's teen pregnancy epidemic (highest among member countries of the Organization for Economic Cooperation and Development) has not yet fully comprehended and addressed by the government.[4] Oaxaca, a state neighboring Central America, is one of the poorest regions, with a population of 3, 976, 297[5], of which 65.7% belong to over ten indigenous groups[6] and protestant religions.[7] In a 2015 census, they reported over 800,000 adolescents (10-19 years) and in 2018, 12,127 births were registered to women aged 15-19.[8]

Approximately 70% of students in Latin America (LA) do not have access to comprehensive sexual education. A study in five LA countries showed that increasing sexual and reproductive health (SRH) literacy can prevent multiple pregnancies as high school dropouts tend to perpetuate the vicious cycle of teen mothers. The chances of experiencing teen pregnancy increased to 53% among adolescents who had no knowledge of their ovulatory cycle and had never used any form of contraception.[9] Unintended pregnancy leads to a gender-inequity gap that widens and perpetuates the intergenerational poverty cycle.[10]

Author α: Senior Researcher, Faculty of Medicine, National Autonomous University of Mexico (UNAM).Ave. Universidad # 3000, Ciudad Universitaria, Coyoacán 04510. Mexico.
e-mail: claudiadiazolavarrieta@gmail.com
Author σ ν: Researcher, Faculty of Medicine, "Benito Juárez" Autonomous University of Oaxaca.Av. Universidad S/N. Ex-Hacienda 5 Señores, Universidad, Universitaria Uabjo, 68120 Oaxaca de Juárez.
Author ρ: Director, Faculty of Medicine, UNAM.Avenida Universidad No. 3000, Colonia Copilco Universidad, Delegación Coyoacán, UNAM, Ciudad Universitaria, Mexico.
Author ω ¥: Researcher, Faculty of Medicine, UNAM.Avenida Universidad No. 3000, Colonia Copilco Universidad, Delegación Coyoacán, UNAM, Ciudad Universitaria, Mexico.
Author § Θ ζ: Researcher, Faculty of Medicine, UNAM. Avenida Universidad No. 3000, Colonia Copilco Universidad, Delegación Coyoacán, UNAM, Ciudad Universitaria, Mexico.
Author χ: National School of Biological Sciences, National Polytechnic Institute.Av. Luis Enrique Erro S/N, Unidad Profesional Adolfo López Mateos Zacatenco, Alcaldía, 07738 Ciudad de México, CDMX.
Author £: Head, Research Division, UNAM. Avenida Universidad No. 3000, Colonia Copilco Universidad, Delegación Coyoacán, UNAM, Ciudad Universitaria, Mexico.
Author €: Director, Faculty of Medicine, Benito Juárez Autonomous University of Oaxaca.

According to UNESCO, "early and unintended pregnancy prevention is one piece of a bigger puzzle", where an effective response from the education sector is needed so adolescents can access quality sexuality education.[11] This is an exploratory, cross-sectional study aimed at documenting adolescent's knowledge on SRH and its correlates with sample characteristics, to better understand the context in which students' from a disadvantaged rural population access information about human sexuality, sexual anatomy, and physiology; reproduction; contraception; as well as correct condom and contraceptive use. We aimed to determine an association between failing scores of enrolled students in knowledge-based and diagrams of the male and female reproductive systems. Assess if their reported sources of information regarding SRH, i.e., parents, teachers, health care centers and the internet, affect their scores.

II. Methods

The research team traveled to Oaxaca to meet with the Ministry of Education and school district municipal representatives to explain the study, request authorization to survey middle school students (grades 7th- 9th, 12-14 years) regarding unmet SRH information needs. The ad-hoc study questionnaire was drafted in collaboration with local partners and adapted to the local context. We carried out a pilot phase among students attending the same school years. As students were underage, we convened a meeting with parents and school principals to obtain informed consent, given the sensitive nature of some questions. We began data collection with partners from Oaxaca State University. All 245 students (male and female) enrolled in grades 7th, 8th, and 9th were eligible and invited to participate, the survey content was explained, and consent requested. All students agreed and signed an informed consent form. Our response rate was 100%. We selected 3 public middle schools located in the Tlacolula, Etla, and Centro school districts. We used convenience sampling and selection bias was addressed by selecting similar public schools (State of Oaxaca Human Development Index (HDI): 0.67; San Pedrolxtlahuaca HDI: 0.64-0.70; San Juan del Estado HDI: 0.64-0.70; San Sebastián Teitipac HDI: 0.59-0.64), [12] and geographically distant while belonging to the region. Fieldwork started after the study protocol was submitted to UNAM's Internal Review Board and approved: FM-DI-028-2017.

Ours was a cross-sectional study that included a multiple-choice paper and pencil self-administered survey with 9 questions covering demographics, 24 questions divided in 3 sections assessing technical knowledge and 5 diagrams. Every participant received colored diagrams, a response sheet, and a survey booklet. Diagram design followed international guidelines.[13,14] (Appendix A). Section 1: female sexuality (Q#1-7), Section 2: male sexuality (Q#8-12), Section 3: modern contraceptive methods (MCM), sources of SRH information (Q#13-22). Diagrams were subdivided into five categories: a) female reproductive system (FRS), b)male reproductive system (MRS), c) anatomical placement of MCM, d) diagrams associated with MCM, and e) 9 steps for correct male condom placement. Sections and diagrams were scored as follows; a failing score included having <60% of incorrect questions. Each question in every section was scored individually, and we obtained a score for the entire survey (3 sections). For the diagram illustrating correct condom placement, students had to correctly identify all 9 to score it correctly. Students took on average 60 minutes to respond to the survey, and we stood by to respond to questions/queries. Students had a day off to participate and answer the survey in their classroom during routine school hours. Survey questions were based on public textbooks from grades 4th, 5th, and 6th. In Mexico, sexuality education begins in the public-school system in grade school four, according to the Ministry of Public Education SRH guidelines. Our questions were based on textbooks and included the minimal level of information every student needs to cover before graduating and enroll in their current school year (Appendix B). We included information only covered in grade 7 because the recent education reform does not include health sciences in grades 8 and 9 (peak years for teen pregnancy). Analysis included all 245 students. We describe sample characteristics, family structure, belonging to an indigenous group, family structure, parents' level of schooling, and year currently enrolled in students classified as failing in the three individual sections, the entire survey, and the diagrams. Variables were included as frequencies and proportions and we determined their association with failing scores using chi-square tests. The dependent variable was obtaining a failing score in individual sections and a failing score for the entire survey and the diagrams. Sample characteristics and sources of SRH information were considered independent variables. We used logistic regression models and the probability of failing associated with sample characteristics and sources of SRH information. Alpha levels were set at 0.05, we calculated odd ratios and carried out statistical analysis, SPSS v. 25.[15]

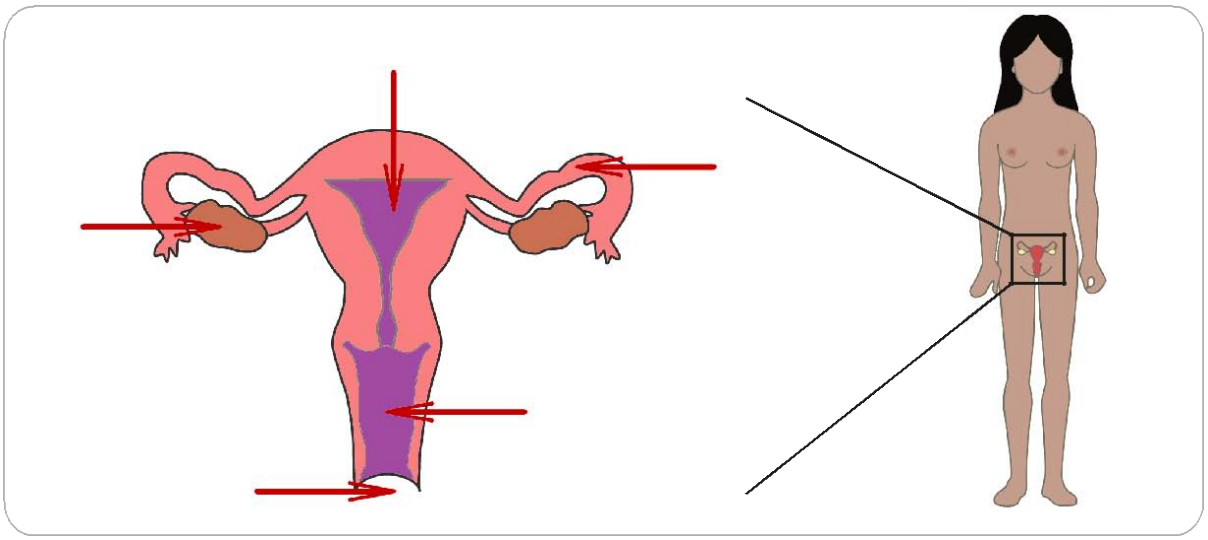

Diagram 1: Female reproductive system

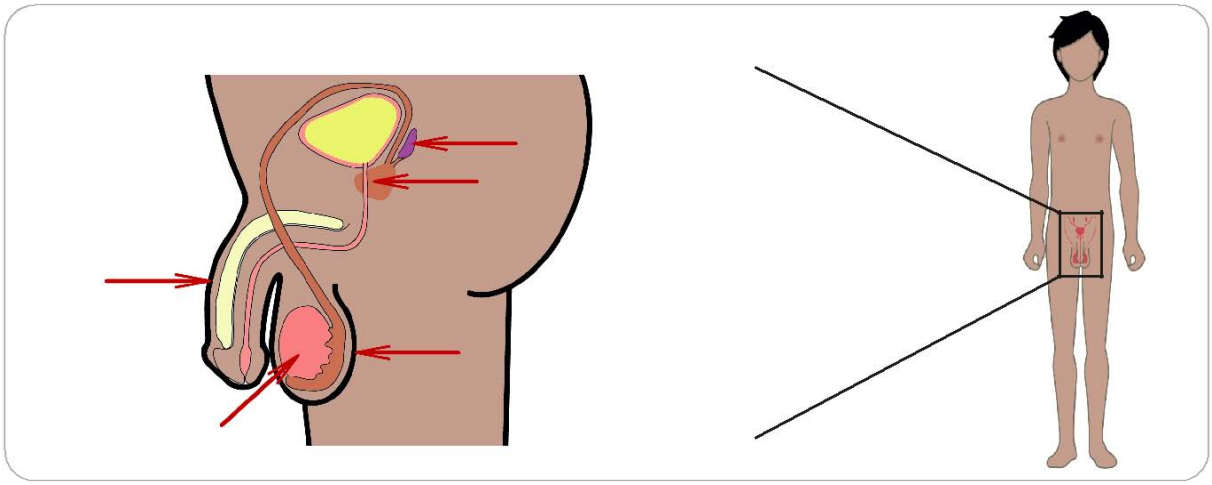

Diagram 2: Male reproductive system

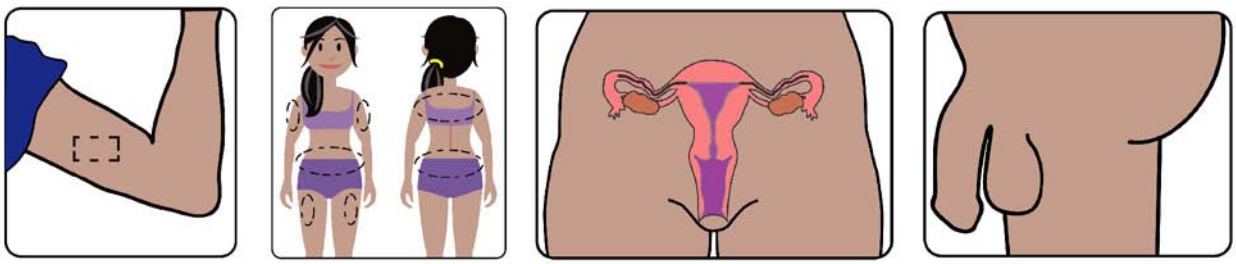

Diagram 3: Anatomic placement of contraceptive methods

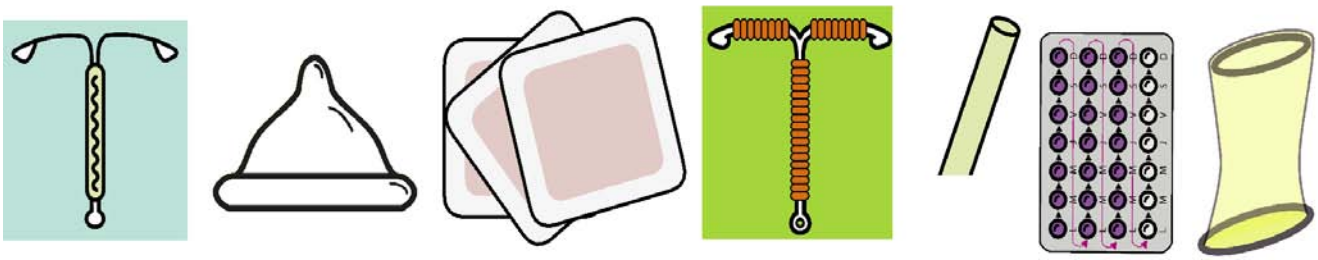

Diagram 4: Schematic diagrams associated with contraceptive methods

III. Results

The school distribution for all 245 students was school A; 50.6% (n=124, 48.4 female), school B; 32.2% (n=79, 45.6% female) and school C; 17.1% (n=42, 71.4 % female). We did not find significant differences across schools in total failing scores ($p>0.05$). All 245 students that were invited to participate responded to the self-administered survey, with a 100% response rate. 51.4% were women; mean age was 13.06 (SD=1.0, p=0.061). 34.3% were currently enrolled in 7th, 30.2% in 8th and 35.5% in 9th grade. The gender distribution across all years was similar ($p>0.05$) (Table 1). Only 12.5% (14 women, 15 men) self-identified as belonging to an indigenous group (we did not enquire language spoken at home, last name, the region of origin, nor skin color).[16] 76.8% of mothers and 77.7% of fathers had completed at least 10 years of schooling (above the 7.5 state average).[17]

Table 1: Sociodemographic characteristics of study sample

	Women	Men	p-value	Total
	126 (51.4)	119 (48.6)	0.654	245
Age($\tilde{x}$)	12.9 (0.9)	13.18 (1.1)	0.061	13.06 (SD=1.0)
	n (%)	n (%)	χ^2	n (%)
School year currently enrolled in (grade)				
7th	48 (38.1)	36 (30.3)	0.206	84 (34.3)
8th	32 (25.4)	42 (35.3)		74 (30.2)
9th	46 (36.5)	41 (34.5)		87 (35.5)
Belongs to indigenous group (self-report)				
No	106 (88.3)	98 (86.7)	0.710	204 (87.5)
Yes	14 (11.7)	15 (13.3)		29 (12.5)
Family structure (lives with)				
Both parents	87 (69)	86 (72.3)	0.824	173 (70.6)
Mother	34 (27)	28 (23.5)		62 (25.3)
Father, grandfather, uncle	5 (4)	5 (4.2)		10 (4.1)
Mother's level of schooling				
Up to high school	60 (54.1)	41 (42.7)	0.190	101(48.8)
High school	30 (27)	28 (29.2)		58 (28.0)
High school+	21 (18.9)	27 (28.1)		48 (23.2)
Father's level of schooling				
Up to high school	48 (52.2)	44 (53)	0.119	92 (52.6)
High school	28 (30.4)	16 (19.3)		44 (25.1)
High school+	16 (17.4)	23 (27.7)		39 (22.3)
Mother's age range (yrs)				
<30	11 (8.9)	16 (14.4)	0.287	27 (11.5)
30 - 40	66 (53.2)	61(55)		127 (50.0)
40+	47(37.9)	34 (30.6)		81 (34.5)
Father's age range (yrs)				
<30	4(3.5)	4 (3.8)	0.703	8 (3.7)
30 - 40	45(39.8)	47 (45.2)		92 (42.4)
40+	64(56.6)	53 (51)		117 (53.9)

*χ^2 test, *95%*

Prevalence failing scores per individual sections were FRS (15.9%), MRS (24.9%), knowledge of MCM (30.6%), and failing score for the entire survey was 34.3%. Table 2 describes the failing scores per section, failing scores for the entire survey and associations by sample characteristics. Failing scores for the FRS were associated with gender and belonging to an indigenous group ($p<0.05$). Failing scores for knowledge of MCM were associated with gender and mother's age ($p<0.05$). Failing scores for the entire survey were associated with gender and belonging to an indigenous group ($p<0.05$). All failing scores in individual sections and the entire survey were associated with students' year of enrollment, with a higher proportion of students in grade 7th with failing scores (individual and total scores). Students responses to section B included

diagrams displaying the anatomical representation of the female and MRS, the anatomical placement and visual recognition of MCM, and a diagram of correct condom placement. The failing score prevalence for the FRS was 50.2%, for the MRS 44.5%, for anatomical placement of MCM 64.9%, for visual recognition of MCM 24.5% and for the diagram of correct condom placement; 20.4%. Table 3 shows how the schematic representation of the FRS and the diagram for correct condom placement were associated with the school year currently enrolled in ($p<0.05$). We found an association among students with failing scores in visual recognition of MCM; 92% of those who failed did not report using the internet as a source of SRH information, and 96% of those who failed the section on correct condom use ($p=0.004$). We found an association between failing scores in the male and FRS diagrams, and approaching their father as a source of SRH information ($p<0.05$); however, 34 and 36% of students who approached their father failed both the male and reproductive systems. After bivariate analysis (Appendix C) we carried out the multivariate analysis. Table 4 includes sample characteristics (gender, school year, indigenous group, and source of SRH information) and its association with failing scores in knowledge-based sections. The failing scores for the FRS were associated with gender; males had a five-fold risk of failing this section compared to women (OR 5.12 [CI 95% 2.12-12.37]), self-identifying as belonging to an indigenous group had an approximate four-fold risk of failure (OR 4.50 [CI 95% 1.71-11.8]), being enrolled in higher years 8th or 9th was a protective factor (OR 0.26 [CI 95% 0.10-0.69]) and (OR 0.33 [CI 95% 0.12-0.87]) respectively. Gender was associated with failing the section on knowledge of MCM; men had a two-fold risk of failing (OR 2.16 [CI 95% 1.20-3.89]).

Table 2: Individual failing scores per section and failing scores for entire survey by sample characteristics

	Failing scores in individual sections							
Sample characteristics	Female reproductive system n=39 (15.9%)		Male reproductive system n=61 (24.9%)		Knowledge of contraceptive methods n=75 (30.6%)		*Failing scores for entire survey* n=84 (34.3%)	
	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value
School year currently enrolled in (grade)								
7th	23(59)	**0.002**	30(49.2)	**0.018**	38(50.7)	**<0.001**	46(54.8)	**<0.001**
8th	8(20.5)		15(24.6)		24(32)		20(23.8)	
9th	8(20.5)		16(26.2)		13(17.3)		18(21.4)	
Gender								
Women	10(25.6)	**<0.001**	30(49.2)	0.685	30(40)	**0.017**	35(41.7)	**0.027**
Men	29(74.4)		31(50.8)		45(60)		49(58.3)	
Belongs to indigenous group (self-report)								
No	25(69.4)	**<0.001**	47(81)	0.083	61(83.6)	0.212	66(81.5)	**0.040**
Yes	11(30.6)		11(19)		12(16.4)		15(18.5)	
Mother's age range (yrs)								
<30	10(25.6)	0.091	10(16.9)	0.301	13(18.6)	**0.037**	13(16.5)	0.170
30 - 40	14(38.9)		29(49.2)		39(55.7)		43(54.4)	
40+	15(41.7)		20(33.9)		18(25.7)		23(29.1)	
Source of SRH information								
The Internet								
No	37(94.1)	**0.023**	57(93.4)	**0.007**	66(88)	0.107	77(91.7)	**0.005**
Yes	2(5.1)		4(6.6)		9(12)		9(12)	
Teacher								
No	35(89.7)	0.123	54(88.5)	0.078	67(89.3)	**0.025**	76(90.5)	**0.006**
Yes	4(10.3)		7(11.5)		8(10.7)		8(9.5)	
Father								
No	24(61.5)	0.093	39(63.9)	0.082	55(73.3)	0.853	54(64.3)	**0.036**
Yes	15(38.5)		22(36.1)		20(26.7)		30(35.7)	

Table 3: Individual failing scores for diagrams and failing scores for each diagram by sample characteristics

	Failing scores for diagrams				
	Female reproductive system schematic diagram n=123 (50.2%)	Male reproductive system schematic diagram n=109 (44.5%)	Anatomical placement of contraceptive methods n=159 (64.9%)	Visual recognition of contraceptive methods n=60 (24.5%)	Schematic diagram of correct condom placement (*9 steps*) n=50 (20.4%)

Sample characteristics	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value
School year currently enrolled in (grade)										
7th	50(40.7)	**0.014**	41(37.6)	0.303	60(37.7)	0.298	24(40)	0.251	20(40)	**0.012**
8th	40(32.5)		35(32.1)		45(28.3)		20(33.3)		21(42)	
9th	33(26.8)		33(30.3)		54(34)		16(26.7)		9(18)	
Father's level of schooling										
Up to high school	44(51.8)	0.838	47(60.3)	0.106	68(58.6)	**0.042**	24(54.5)	0.936	24(64.9)	0.202
High school	23(27.1)		14(17.9)		23(19.8)		11(25)		8(21.6)	
High school+	18(21.2)		17(21.8)		25(21.6)		9(20.5)		5(13.5)	
Gender										
Women	57(46.3)	0.110	56(51.4)	0.988	78(49.1)	0.312	30(50)	0.799	27(54)	0.683
Men	66(53.7)		53(48.6)		81(50.9)		30(50)		23(46)	
Source of SRH information										
The Internet										
No	102(82.9)	0.717	94(86.2)	0.125	130(81.8)	0.877	55(91.7)	**0.025**	48(96)	**0.004**
Yes	21(17.1)		15(13.8)		29(18.2)		5(8.3)		2(4)	
Mother										
No	45(36.6)	0.856	41(37.6)	0.891	59(37.1)	0.987	25(41.7)	0.404	27(54)	**0.006**
Yes	78(63.4)		68(62.4)		100(62.9)		35(58.3)		23(46)	
Father										
No	81(65.9)	**0.018**	70(64.2)	**0.009**	112(70.4)	0.315	39(65)	0.132	37(74)	0.795
Yes	42(34.1)		39(35.8)		47(29.6)		21(35)		13(26)	
Boyfriend/girlfriend										
No	121(98.4)	0.993	108(99.1)	0.429	156(98.1)	0.670	57(95)	**0.018**	49(98)	0.818
Yes	2(1.6)		1(0.9)		3(1.9)		3(5)		1(2)	
Other										
No	113(91.9)	**0.019**	106(97.2)	0.164	149(93.7)	0.170	56(93.3)	0.465	45(90)	0.061
Yes	10(8.1)		3(2.8)		10(6.3)		4(6.7)		5(10)	

* χ^2 test,*95%*

Students who used the Internet as a source for SRH information displayed a protective factor when answering MRS (OR 0.30 [CI 95% 0.10-0.90]). Being male was associated with failing sections on knowledge of MCM (OR 2.16 [CI 95% 1.20-3.89]) and with year enrolled in; when they reach grade 9 (compared to 8th(OR 0.51 [CI 95% 0.26-0.41]) being in school seems to be less protective (OR 0.20 [CI 95% 0.09-0.41]). Failing scores for the entire survey were associated with gender and indigenous group; men had a (OR 2.23 [CI 90% 1.21-4.09]) and those self-identified as indigenous (OR 2.11 [CI 90% 0.89-5]). For failing scores in the entire survey, being male was also a risk factor and enrolled in 8th grade (OR 0.26 [CI 95% 0.13-0.54]) and 9th (OR 0.23 [CI 95% 0.11-0.48]) was protective (Table 4).

Table 4: Multivariate analysis of individual and failing scores for entire survey by sample characteristics

	Failing scores							
	Model 1 Female reproductive system		Model 2 Male reproductive system		Model 3 Knowledge of contraceptive methods		Model 4 Entire survey	
Sample characteristics	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%
Gender								
Women	1				1		1	
Men	5.12***	(2.12 - 12.37)	-	-	2.42***	(1.33 - 4.41)	2.23***	1.21-4.09
School year currently enrolled in (grade)								
7th	1		1		1		1	
8th	0.26***	(0.10 - 0.69)	0.49*	(0.23 - 1.01)	0.50**	(0.25 - 0.98)	0.26***	(0.13 - 0.54)
9th	0.33**	(0.12 - 0.87)	0.50*	(0.24 - 1.03)	0.20***	(0.09 - 0.42)	0.23***	(0.11 - 0.48)
Belongs to an indigenous group (by self-report)								
No	1						1	

Yes	4.50***	(1.71 - 11.87)	-	-	-	-	2.11*	(0.89 - 5.00)
Sourceof SRH Information								
The Internet								
No	1		1				1	
Yes	0.24*	(0.05 - 1.16)	0.30**	(0.10 - 0.90)	-	-	0.41*	(0.16 - 1.04)
Healthcare center								
No					1			
Yes					0.33**	(0.13 - 0.88)		

*** p<0.01, ** p<0.05, * p<0.1 (borderline)

Gender was not associated with failing scores in students' recognition of diagrams. When students were asked to identify diagrams of the female and MRS, being in 9th grade (vs 7th) was considered a protective factor for not failing the diagrams of the FRS (OR 0.43 [CI 95% 0.23-0.81]). We found an association between being enrolled in grade 8th and not failing the MRS diagram (OR 0.37 [CI 95% 0.17-0.82]). Students (male and female) who asked their fathers about SRH information compared to those who did not, had an almost two-fold risk of failing the section on the FRS (OR 1.90 [CI 95% 1.05-3.43]) and the MRS (OR 2.48 [CI 95% 1.24-4.96]). Failing scores on anatomical placement of MCM were significantly associated with father's level of schooling; those with completed high school (compared with those with <high school) yielded an (OR 0.49 [CI 95% 0.25-0.95]). Students self-identifying as indigenous had a two-fold risk of failing the visual recognition of MCM (OR 2.38 [CI 95% 1.05-5.42]) and using the internet as a source of reference for this section was a protective factor (OR 0.33 [CI 95% 0.12-0.89]). Lastly, failing scores for correct condom placement were associated with the use of the internet as a source of SRH information as a protective factor(OR 0.18 [CI 95% 0.04-0.81])(Table 5).

Table 5: Multivariate analysis of individual and failing scores for each diagram by sample characteristics

	Model 1 Female reproductive system schematic diagram		Model 2 Male reproductive system schematic diagram		Model 3 Anatomical placement of contraceptive methods		Model 4 Visual recognition of CM		Model 5 Schematic diagram of correct condom placement (9 steps)	
Failing scores:	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%
School year currently enrolled in (grade)										
7th	1		1						1	
8th	0.70	(0.36 - 1.33)	0.37**	(0.17 - 0.82)	-	-	-	-	1.19	(0.56 - 2.52)
9th	0.39***	(0.21 - 0.74)	0.67	(0.31 - 1.48)	-	-	-	-	0.34**	(0.13 - 0.85)
Belongs to an indigenous group (by self-report)										
No							1			
Yes	-	-	-	-	-	-	2.38**	(1.05 - 5.42)	-	-
Father's level of schooling										
High school	-	-	-	-	1 0.49**	(0.25 - 0.95)	-	-	-	-
High school +	-	-	-	-	0.64	(0.31 - 1.32)	-	-	-	-
Source of SRH information:										
Mother										
No									1	
Yes									0.35***	(0.18 - 0.69)
Father										
No	1		1							
Yes	2.08**	(1.14 - 3.79)	2.48**	(1.24 - 4.96)	-	-	-	-	-	-
The Internet										

No							1		1	
Yes	-	-	-	-	-	-	0.33**	(0.12 - 0.89)	0.16**	(0.04 - 0.73)
Other										
No										
Yes	7.65**	(1.58 - 36.93)							3.32*	(0.85 - 12.92)

*** p<0.01, ** p<0.05, * p<0.1

IV. Discussion

Our exploratory study describes SRH knowledge among students currently enrolled in 7th, 8th, and 9th grade in a rural public middle school in Oaxaca. We found an association between grade of enrollment and knowledge of male and FRS; school appears to be a protective factor as there is a slight difference between grades 8 and 9, however, knowledge of MCM decreases by grade 9 when they are most in need of information as the median age for adolescent's sexual debut is 15, our participants have scant knowledge of MCM,[18] and Oaxaca is the third state with the highest rate of teen pregnancy.[19] In Mexico, adolescents receive sex education from public schools and most sexuality education topics are covered by middle school.[20,21] While the content would need to be consistent with the grade level, our results show otherwise. Basic knowledge of male and FRS is taught in middle school and reviewed in grade 7th together with MCM. So as not to create detrimental information gaps, students would need to continue receiving information on MCM during grades 8 and 9 to comply with UNESCO's 2009 guidelines on comprehensive sexuality education curricula.[22] Adolescents face significant challenges when accessing and learning about consistent contraceptive use. We showed ethnic inequities among students self-identifying as indigenous vs those who do not. In our study, 12.5% of students who self-identified as indigenous (in Oaxaca 65.7% belong to one) had a two-fold risk (2.38) of failing the visual recognition of MCM and a four-fold risk of failing the FRS. In 2014 women who spoke an indigenous language reported a higher uptake of MCM in their first sexual encounter compared with data from 2009 (4.9% vs 11.8%). The reasons why indigenous women do not access MCM is primarily due to a lack of knowledge of where to obtain them and not knowing how to use them.[23]

In our question on correct condom use, only 20% failed, 24.5% failed the visual recognition of MCM and 64.9% failed the anatomical placement of MCM. If students are unable to correctly identify the anatomical site of MCM this will become their strongest barrier to use, together with the fact that they are unable to identify them. The latter is consistent with data from surveys where 84.5% of women report using condoms in the first sexual encounter.[23] As per our results, this may due to their lack of information on other MCM with higher effectiveness rates; Mexican adolescents continue favoring condoms over other effective methods as part of their sexual debut. A third of adolescents (28.6%) who chose not to use a contraceptive method during their first sexual encounter reported "not knowing where to get them or how to use them"[23], which is consistent with the 24.5% of our participants being unable to visually identify MCM. Gender (male) was associated with failing scores in all the knowledge-based sections; FRS and MCM. In contrast, male (50.9%) and female (49.1%) students had similar failing scores in diagrams; both were unable to identify anatomical placement of MCM, visual recognition of MCM showed similar failing scores (50% vs 50%). In traditional societies, the responsibility of contraception is often placed in the hands of women, we may hypothesize that our male participants are failing the knowledge questions because they are replicating the standard where they do not feel it is up to them to prevent a pregnancy; thus are not fully engaged in SRH programs and it appears as if condoms are their only viable alternative. A recent ethnographic study done in rural communities with the highest teen pregnancy rates reports girls also expect their boyfriend/partner will take care of them (i.e., use a MCM) in their first sexual encounter.[24] We also explored the sources of SRH information reported by students. In our multivariate analysis, we did not find an association between failing any section (knowledge and diagrams) and approaching teachers, friends/ boyfriend/girlfriend, and not approaching anyone. We found an association between internet use and knowledge of the MRS, visual recognition of MCM, and correct condom use. Our prevalence of internet use (17%) was high considering that in 2018, 5.3% of rural households in Oaxaca reported having internet access[25]; therefore. we estimate that students may be accessing SRH on their mobile phones.[26] Evidence suggests mobile phones are useful to reach vulnerable populations and have the potential to generate changes in knowledge and behavior.[26,27] We need to implement a strategic approach whereby adolescents access SRH education and services via m Health- use of mobile phones to improve health behaviors and services- a technical area that has witnessed an increased interest and promise in high and middle-income countries.[26] Of all internet users in Oaxaca, 23.6% access it in school and 24% in free public spaces.[25] Despite limited internet access among this population, the internet was considered an adequate learning tool in our study as it provided sufficient

knowledge, and its use improved students' scores. It was the most reliable source of SRH information regarding knowledge of the MRS and visual recognition of MCM.

Parents have a unique opportunity to transmit knowledge and information about potential sexual risks and instill confidence and safety around adolescents' sexual choices.[28] Strategies parents adopt regarding SRH have repercussions on adolescent's sexual behavior; however, most parent-adolescent SRH communication research comes from high-income countries, and there is a dearth of information in low-and middle-income countries (LMIC).[29] Adolescents from LMIC, living in rural areas, continue to face social and health challenges.[30] However, in our study, male and female students who approached their father (52.6% had primary school or no schooling) as a source of SRH information, were associated with 1.9 greater risk of failing. In a traditional society such as Oaxaca, what students learn about SRH is taught by their father and not their mother.[31] If parents are sensitized about the risks that adolescence involves, it will be easier to promote sexuality education, prevention of sexually transmitted infections and unintended pregnancy through more effective parent–adolescent communication strategies, and evidence-based SRH information.[32] Parents need to know that in Mexico, 23% of adolescents begin their sexual life between 12-19 years; of these, 15% of men and 33% of women did not use any MCM in their first sexual encounter. Thus, according to these data, approximately 340,000 births occur per year in women under 19.[33] One of the biggest challenges SRH education has is the way it is taught to children and adolescents. In our study, the biggest hurdle was students' difficulty to correctly identify diagrams of the male and FRS, anatomical placement of MCM, and correct identification of MCM. To promote the inclusion of students from rural areas, we need to implement innovative and effective online teaching methods (i.e., WhatsApp) while acknowledging internet access is poor. A study examined the impact of audio-visual media in SRH knowledge among 153 middle-school students. Findings showed that audio-visual media significantly improves SRH knowledge among adolescents.[34] If our study participants displayed more difficulty in sections involving diagrams (vs the knowledge-based questions), perhaps we must center our efforts on learning tools with graphic and brief content that have the potential to "remain in the minds of those who simply glance at them".[35] In the context of the SARS-CoV-2 pandemic, the government estimates that between 2020-2021 there will be a 20% increase in teen pregnancies equivalent to 21,575 pregnancies associated with an unmet contraceptive need.[36] If we take into account that: a) schools closed as of March 23, 2020 and education is currently offered via television; b) schools in rural settings traditionally have limited resources, lack adequate infrastructure including trained teachers in charge of providing evidence-based SRH information; c) there has been an increase in school desertion; d) the absence of the lay state complicates the lack of available information parents of adolescents have regarding SRH topics; e) Mexico hosts a teen pregnancy epidemic; f) our study participants had a high percentage of failing scores when asked about SRH topics they had covered during primary school. The latter points towards a pressing need to promote SRH education at all levels of middle school to help reduce adolescent pregnancy.

V. Conclusion

The internet must become an alternative learning medium on SRH topics and part of traditional teaching especially because the information our participants receive from their parents is inadequate and was associated with the risk of obtaining failing scores. SRH must be taught as a continuum and not only in grade 7th because school decreases as a protective factor as the year of enrollment increases. Our data was collected before the SARS-CoV-2 pandemic. As online education becomes an integral part of the New Normal, Oaxaca's government will need to expand/ strengthen internet coverage for students to continue learning the context-specific SRH curricula that will allow them to flourish.

Study limitations: We only surveyed three public middle schools, and while we got a 100% response rate, we would benefit from sampling schools from other regions. Our methodology does not allow for causal inferences about the associations found, and we were unable to follow-up our participants to enquire if after their participation, they had sought other sources of SRH information. Students belonging to an indigenous group were at a disadvantage; a translation of the survey into their language would reflect more accurately their level of knowledge and eliminate the bias of responding in Spanish.

List of abbreviations

LA- Latin America
SRH- Sexual and reproductive health
HDI- Human Development Index
MCM- Modern Contraceptive Methods
FRS- Female reproductive system
MRS- Male reproductive system
LMIC- Low- and middle-income countries

Declarations

Ethics approval and consent to participate: Faculty of Medicine (IRB #: FM-DI-028-2017).

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests

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Authors' contributions: All authors contributed to the study design. CDO: coordinated the research project, drafted, and edited the manuscript. CGA: data analysis and manuscript edition. SGM: data analysis. ARV: data analysis and results interpretation. MBAA: IRB submission and data collection. BCC: data collection. MISG: material preparation and data collection. VJP: manuscript edition. VCS: manuscript edition and submission. GEFD: manuscript edition. RGG: coordinated the research project and edited the manuscript. All authors read and approved the final manuscript.

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APPENDIX C- Additional tables

Table 1A: Bivariate analysis of individual and failing scores for entire survey by sample characteristics.

	Failing scores in individual sections						*Failing scores for entire survey*	
Failing scores:	Female reproductive system		Male reproductive system		Knowledge of contraceptive methods		Failing scores for entire survey	
	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%
Gender								
Men	3.74***	(1.73 - 8.07)	1.13	(0.63 - 2.01)	1.95**	(1.12 - 3.38)	1.82**	(1.07 - 3.10)
School year currently enrolled in (grade)								
8th	0.32**	(0.13 - 0.77)	0.46**	(0.22 - 0.94)	0.58	(0.30 - 1.11)	0.31***	(0.16 - 0.60)
9th	0.27***	(0.11 - 0.64)	0.41**	(0.20 - 0.82)	0.21***	(0.10 - 0.44)	0.22***	(0.11 - 0.42)
Belongs to indigenous group (by self-report)								
Yes	4.38***	(1.85 - 10.33)	2.04*	(0.90 - 4.62)	1.65	(0.75 - 3.67)	2.24**	(1.02 - 4.91)
Family structure (lives with)								
Mother	1.42	(0.66 - 3.04)	1.08	(0.56 - 2.11)	0.73	(0.38 - 1.39)	0.58*	(0.30 - 1.10)
Father/other	1.48	(0.30 - 7.38)	1.34	(0.33 - 5.40)	0.90	(0.22 - 3.59)	0.71	(0.18 - 2.85)
Mother's level of schooling								
Grade school	1.39	(0.60 - 3.18)	0.91	(0.44 - 1.89)	0.98	(0.48 - 1.99)	1.00	(0.50 - 2.00)
Grade school +	0.76	(0.28 - 2.08)	0.37**	(0.14 - 0.97)	0.88	(0.41 - 1.89)	0.69	(0.32 - 1.49)
Father's level of schooling								
Grade school	0.81	(0.29 - 2.26)	0.83	(0.36 - 1.94)	1.12	(0.53 - 2.38)	0.83	(0.38 - 1.80)
Grade school+	1.12	(0.42 - 3.01)	0.73	(0.30 - 1.81)	0.51	(0.21 - 1.24)	0.77	(0.34 - 1.76)
Mother's age range (yrs)								
30 - 40	0.35**	(0.13 - 0.99)	0.50	(0.21 - 1.22)	0.48*	(0.21 - 1.11)	0.55	(0.24 - 1.28)
> 40	0.65	(0.23 - 1.81)	0.56	(0.27 - 1.28)	0.31**	(0.12 - 0.77)	0.43*	(0.17 - 1.05)
Father's age range (yrs)								
30 - 40	1.15	(0.13 - 10.15)	1.00	(0.19 - 5.30)	0.93	(0.21 - 4.15)	0.98	(0.22 - 4.35)
>40	1.27	(0.15 - 10.98)	0.94	(0.18 - 4.94)	0.63	(0.14 - 2.78)	0.77	(0.17 - 3.40)

*** p<0.01, ** p<0.05, * p<0.1

Table 1B: Bivariate analysis of failing scores for all diagrams by sample characteristics.

	Failing scores in individual diagrams									
Failing scores:	Female reproductive system schematic diagram		Male reproductive system schematic diagram		Anatomical placement of contraceptive method		Visual recognition of CM		Schematic diagram of correct condom placement (*9 steps*)	
	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%
Gender										
Men	1.51	(0.91 - 2.49)	1.00	(0.61 - 1.66)	1.31	(0.77 - 2.22)	1.08	(0.60 - 1.93)	0.88	(0.47 - 1.64)
School year currently enrolled in (grade)										

8th	0.80	(0.43 - 1.50)	0.94	(0.50 - 1.76)	0.62	(0.32 - 1.21)	0.93	(0.46 - 1.86)	1.27	(0.62 - 2.59)
9th	0.42***	(0.22 - 0.77)	0.64	(0.35 - 1.18)	0.65	(0.34 - 1.24)	0.56	(0.27 - 1.16)	0.37**	(0.16 - 0.87)
Belongs to indigenous group (by self-report)										
Yes	1.47	(0.67 - 3.24)	1.59	(0.73 - 3.48)	0.97	(0.43 - 2.20)	2.36**	(1.05 - 5.29)	1.97	(0.83 - 4.66)
Family structure (lives with)										
Mother	0.73	(0.41 - 1.31)	0.49**	(0.27 - 0.91)	0.66	(0.36 - 1.20)	0.52*	(0.24 - 1.10)	0.60	(0.27 - 1.33)
Father/other	2.20	(0.55 - 8.80)	0.69	(0.19 - 2.53)	0.72	(0.19 - 2.65)	1.15	(0.29 - 4.63)	1.52	(0.38 - 6.17)
Mother's level of schooling										
Grade school	0.84	(0.44 - 1.60)	1.01	(0.53 - 1.94)	0.49**	(0.25 - 0.95)	0.68	(0.31 - 1.49)	0.79	(0.36 - 1.77)
Grade school+	1.10	(0.56 - 2.20)	0.82	(0.41 - 1.64)	0.64	(0.31 - 1.32)	0.76	(0.33 - 1.74)	0.68	(0.28 - 1.65)
Father's level of schooling										
Grade school	1.19	(0.58 - 2.45)	0.45**	(0.21 - 0.95)	0.39**	(0.18 - 0.82)	0.94	(0.41 - 2.16)	0.63	(0.26 - 1.54)
Grade school +	0.94	(0.44 - 1.98)	0.74	(0.35 - 1.57)	0.63	(0.28 - 1.41)	0.85	(0.35 - 2.05)	0.42	(0.15 - 1.19)
Mother's age range (yrs)										
30 - 40	0.64	(0.27 - 1.48)	1.52	(0.65 - 3.58)	0.62	(0.24 - 1.57)	0.62	(0.25 - 1.52)	0.44*	(0.18 - 1.11)
40+	0.61	(0.25 - 1.47)	1.23	(0.50 - 3.02)	0.60	(0.23 - 1.57)	0.61	(0.24 - 1.59)	0.53	(0.20 - 1.39)
Father's age range (yrs)										
30 - 40	0.53	(0.12 - 2.33)	3.00	(0.58 - 15.65)	1.24	(0.28 - 5.54)	1.06	(0.20 - 5.61)	0.89	(0.17 - 4.73)
40+	0.68	(0.15 - 2.96)	2.24	(0.43 - 11.56)	1.11	(0.25 - 4.89)	0.94	(0.18 - 4.94)	0.82	(0.15 - 4.29)

*** p<0.01, ** p<0.05, * p<0.1

Table 1C: Individual failing scores per section and failing scores for entire surveyby source of SRH information

	Failing scores in individual sections							
Source of SRH information	Female reproductive system n=39 (15.9%)		Male reproductive system n=61 (24.9%)		Knowledge of contraceptive methods n=75 (30.6%)		*Failing scores for entire survey* n=84 (34.3%)	
	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value
Mother								
No	16(41)	0.584	19(31.1)	0.263	31(41.3)	0.367	30(35.7)	0.738
Yes	23(59)		42(68.9)		44(58.7)		54(64.3)	
Father								
No	24(61.5)	0.093	39(63.9)	0.082	55(73.3)	0.853	54(64.3)	**0.036**
Yes	15(38.5)		22(36.1)		20(26.7)		30(35.7)	
Teacher								
No	35(89.7)	0.123	54(88.5)	0.078	67(89.3)	0.025	76(90.5)	**0.006**
Yes	4(10.3)		7(11.5)		8(10.7)		8(9.5)	

Friends								
No	36(92.3)	0.692	59(96.7)	0.059	70(93.3)	0.332	79(94)	0.183
Yes	3(7.7)		2(3.3)		5(6.7)		5(6)	
Health care center								
No	31(79.5)	0.303	53(86.9)	0.617	69(92)	**0.039**	74(88.1)	0.313
Yes	8(20.5)		8(13.1)		6(8)		6(8)	
Boyfriend/girlfriend								
No	30(50)	0.380	61(100)	0.246	75(100)	0.180	83(98.8)	0.693
Yes	0(0)		0(0)		0(0)		1(1.2)	
The Internet								
No	13(21.7)	0.023	57(93.4)	**0.007**	66(88)	0.107	77(91.7)	**0.005**
Yes	2(5.1)		4(6.6)		9(12)		9(12)	
Other								
No	36(92.3)	0.378	60(98.4)	0.174	72(96)	0.665	82(97.6)	0.187
Yes	3(7.7)		1(1.6)		3(4)		2(2.4)	
Does not ask anyone								
No	32(82.1)	0.423	51(83.6)	0.512	62(82.7)	0.299	69(82.1)	0.193
Yes	7(17.9)		10(16.4)		13(17.3)		15(17.9)	

χ^2 test,95%

Table 1D: Failing scores for each diagram by source of SRH information

Source of SRH information:	Female reproductive system schematic diagram n=123 (50.2%)		Male reproductive system schematic diagram n=109 (44.5%)		Anatomical placement of contraceptive methods n=159 (64.9%)		Visual recognition of contraceptive methods n=60 (24.5%)		Schematic diagram of correct condom placement (*9 steps*) n=50 (20.4%)	
	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value
Mother										
No	45(36.6)	0.856	41(37.6)	0.891	59(37.1)	0.987	25(41.7)	0.404	27(54)	**0.006**
Yes	78(63.4)		68(62.4)		100(62.9)		35(58.3)		23(46)	
Father										
No	81(65.9)	**0.018**	70(64.2)	**0.009**	112(70.4)	0.315	39(65)	0.132	37(74)	0.795
Yes	42(34.1)		39(35.8)		47(29.6)		21(35)		13(26)	
Teacher										
No	99(80.5)	0.896	91(83.5)	0.342	129(81.1)	0.864	51(85)	0.344	42(84)	0.522
Yes	24(19.5)		18(16.5)		30(18.9)		9(15)		8(16)	
Friends										
No	112(91.1)	0.811	101(92.7)	0.325	145(91.2)	0.671	55(91.7)	0.747	44(88)	0.478
Yes	11(8.9)		8(7.3)		14(8.8)		5(8.3)		6(12)	
Health care center										
No	105(85.4)	0.837	92(84.4)	0.847	140(88.1)	0.061	54(90)	0.204	44(88)	0.492
Yes	18(14.6)		17(15.6)		19(11.9)		6(10)		6(12)	
Boyfriend/girlfriend										
No	121(98.4)	0.993	108(99.1)	0.429	156(98.1)	0.670	57(95)	**0.018**	49(98)	0.818
Yes	2(1.6)		1(0.9)		3(1.9)		3(5)		1(2)	

The Internet										
No	102(82.9)	0.717	94(86.2)	0.125	130(81.8)	0.877	55(91.7)	**0.025**	48(96)	**0.004**
Yes	21(17.1)		15(13.8)		29(18.2)		5(8.3)		2(4)	
Other										
No	113(91.9)	**0.019**	106(97.2)	0.164	149(93.7)	0.170	56(93.3)	0.465	45(90)	0.061
Yes	10(8.1)		3(2.8)		10(6.3)		4(6.7)		5(10)	
They do not ask anyone										
No	109(88.6)	0.257	90(82.6)	0.150	139(87.4)	0.424	50(83.3)	0.472	41(82)	0.345
Yes	14(11.4)		19(17.4)		20(12.6)		10(16.7)		9(18)	

χ^2 test,95%

Table 1E: Bivariate analysis of individual and failing scores for entire survey by sample characteristics

	Failing scores in individual sections						*Failing scores for entire survey*	
Source of SRH information:	Female reproductive system		Male reproductive system		Knowledge of contraceptive methods		Failing scores for entire survey	
	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%
Mother								
No	1		1		1		1	
Yes	0.82	(0.41 - 1.65)	1.42	(0.77 - 2.64)	0.77	(0.44 - 1.35)	1.10	(0.63 - 1.90)
Father								
No	1		1		1		1	
Yes	1.84*	(0.90 - 3.77)	1.73*	(0.93 - 3.22)	0.94	(0.51 - 1.74)	**1.85****	**(1.04 - 3.29)**
Teacher								
No	1		1		1			
Yes	0.43	(0.15 - 1.29)	0.47*	(0.20 - 1.10)	**0.40****	**(0.18 - 0.91)**	**0.33*****	**(0.15 - 0.74)**
Friends								
No	1		1		1		1	
Yes	0.78	(0.22 - 2.75)	0.26*	(0.06 - 1.16)	0.60	(0.22 - 1.69)	0.50	(0.18 - 1.41)
Health care center								
No	1		1		1		1	
Yes	1.58	(0.66 - 3.76)	0.81	(0.35 - 1.87)	**0.39****	**(0.16 - 0.98)**	0.67	(0.31 - 1.46)
Boyfriend/girlfriend								
No	-	-	-	-	-	-	1	
Yes	-	-	-	-	-	-	0.63	(0.06 - 6.20)
The Internet								
No	1		1		1		1	
Yes	**0.21****	**(0.05 - 0.91)**	**0.25****	**(0.09 - 0.74)**	0.53	(0.24 - 1.16)	**0.30*****	**(0.13 - 0.72)**
Other								
No	1		1		1		1	
Yes	1.82	(0.47 - 7.06)	0.26	(0.03 - 2.07)	0.75	(0.20 - 2.83)	0.37	(0.08 - 1.72)
Does not ask anyone								
No	1		1		1		1	
Yes	1.45	(0.58 - 3.61)	1.31	(0.59 - 2.92)	1.49	(0.70 - 3.16)	1.62	(0.78 - 3.39)

*** p<0.01, ** p<0.05, * p<0.1

Table 1F: Bivariate analysis of failing scores for all diagrams by sample characteristics

	Failing scores in individual diagrams									
Source of SRH information	Female reproductive system schematic diagram		Male reproductive system schematic diagram		Anatomical placement of contraceptive method		Visual recognition of CM		Schematic diagram of correct condom placement (*9 steps*)	
	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%
Mother										
No	1		1		1		1		1	
Yes	1.05	(0.62 - 1.76)	0.96	(0.57 - 1.62)	1.00	(0.58 - 1.73)	0.78	(0.43 - 1.41)	**0.42*** **	**(0.22 - 0.78)**
Father										
No	1		1		1		1		1	
Yes	**1.99 ****	**(1.12 - 3.54)**	**2.13*** **	(1.20 - 3.77)	1.36	(0.74 - 2.50)	1.62	(0.86 - 3.02)	0.91	(0.45 - 1.84)
Teacher										
No	1		1		1		1		1	
Yes	1.04	(0.55 - 1.97)	0.73	(0.38 - 1.40)	0.94	(0.49 - 1.83)	0.68	(0.31 - 1.51)	0.76	(0.33 - 1.75)
Friends										
No	1		1		1		1		1	
Yes	0.90	(0.38 - 2.13)	0.64	(0.26 - 1.57)	0.83	(0.34 - 2.00)	0.84	(0.30 - 2.38)	1.43	(0.53 - 3.83)
Health care center										
No	1		1		1		1		1	
Yes	0.93	(0.46 - 1.87)	1.07	(0.53 - 2.16)	0.51 *	(0.25 - 1.04)	0.55	(0.22 - 1.40)	0.72	(0.28 - 1.84)
Boyfriend/ girlfriend										
No	1		1		1		1		1	
Yes	0.99	(0.14 - 7.16)	0.41	(0.04 - 4.00)	1.63	(0.17 - 15.96)	9.68*	(0.99 - 94.92)	1.31	(0.13 - 12.83)
The Internet										
No	1		1		1		1		1	
Yes	0.89	(0.46 - 1.70)	0.59	(0.30 - 1.16)	1.06	(0.53 - 2.10)	**0.34****	**(0.13 - 0.91)**	**0.15****	**(0.04 - 0.65)**
Other										
No	1		1		1		1		1	
Yes	**5.31 ****	**(1.14 - 24.76)**	0.40	(0.11 - 1.51)	2.82	(0.60 - 13.17)	1.58	(0.46 - 5.45)	2.98*	(0.91 - 9.84)
Does do not ask anyone										
No	1		1		1		1		1	
Yes	0.66	(0.31 - 1.37)	1.70	(0.82 - 3.53)	0.74	(0.35 - 1.55)	1.34	(0.60 - 3.00)	1.49	(0.65 - 3.44)

*** p<0.01, ** p<0.05, * p<0.1

Table 1G: Associations between source of SRH information and sample characteristics

	Source of SRH information*							
	Mother n= 154(62.9%)		Father n=67 (27.5%)		Teacher n=47 (19.2%)		Friends n=23 (9.4%)	
	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value
Gender								
Women	93(60.4)	**0.000**	24(35.8)	**0.003**	24(51.1)	0.956	12(52.2)	0.940
Men	61(39.6)		43(64.2)		23(48.9)		11(47.8)	
School year currently enrolled in (grade)								
7th	61(39.6)	**0.042**	22(32.8)	**0.036**	6(12.8)	**0.001**	3(13)	0.064
8th	46(29.9)		28(41.8)		15(31.9)		8(34.8)	

9th	47(30.5)		17(25.4)		26(55.3)		12(52.2)	
Belongs to indigenous group (self-report)								
Yes	129(88.4)	0.631	61(93.8)	0.068	43(91.5)	0.360	19(86.4)	0.859
No	17(11.6)		4(6.2)		4(8.5)		3(13.6)	
Family structure (lives with)								
Both parents	110(71.4)	0.688	61(91)	**0.000**	28(59.6)	0.173	10(43.5)	**0.011**
Mother	39(25.3)		5(7.5)		16(34)		11(47.8)	
Father, grandfather, uncle	5(3.2)		1(1.5)		3(6.4)		2(8.7)	
Mother's level of schooling								
Up to high school	69(50.4)	0.241	26(44.8)	0.781	20(51.3)	0.461	12(54.5)	0.812
High school	41(29.9)		17(29.3)		8(20.5)		5(22.7)	
High school+	27(19.7)		15(25.9)		11(28.2)		5(22.7)	
Father's level of schooling								
Up to high school	61(54.5)	0.533	21(40.4)	0.097	16(50)	0.914	13(81.3)	**0.049**
High school	29(25.9)		17(32.7)		8(25)		1(6.3)	
High school+	22(19.6)		14(26.9)		8(25)		2(12.5)	
Mother's age range (yrs)								
<30	19(12.7)	0.510	8(12.5)	0.623	1(2.2)	**0.024**	2(9.1)	0.273
30 - 40	77(51.3)		37(57.8)		23(50)		9(40.9)	
40+	54(36)		19(29.7)		22(47.8)		11(50)	
Father's age range (yrs)								
<30	6(4.3)	0.658	2(3.1)	0.224	1(2.4)	0.233	1(5.6)	0.881
30 - 40	56(40.6)		33(51.6)		13(31.7)		7(38.9)	
40+	76(55.1)		29(45.3)		27(65.9)		10(55.6)	

** Students who responded / answered affirmatively to these sources of SRH information; χ^2 test,95%*

Table 1H: Associations between source of SRH information and sample characteristics

	Source of SRH information*									
	Health center n=37 (15.1%)		Boyfriend/girlfriend n=4 (1.6%)		The Internet n= 44(17.9%)		Other n= 12(4.9%)		Does not ask anyone n=34 (13.9%)	
	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value
Gender										
Women	14(37.8)	0.073	3(75)	0.073	23(52.3)	0.902	6(50)	0.919	16(47.1)	0.583
Men	23(62.2)		1(25)		21(47.7)		6(50)		18(52.9)	
School year currently enrolled in (grade)										
7th	11(29.7)	0.565	1(25)	0.565	6(13.6)	**0.000**	2(16.7)	0.381	12(35.3)	0.360
8th	10(27)		1(25)		11(25)		4(33.3)		7(20.6)	
9th	16(43.2)		2(50)		27(61.4)		6(50)		15(44.1)	
Belongs to indigenous group (self-report)										
No	28(77.8)	0.053	3(75)	0.053	38(88.4)	0.857	9(75)	0.176	28(87.5)	0.992
Yes	8(22.2)		1(25)		5(11.6)		3(25)		4(12.5)	
Family structure (lives with)										

Both parents	27(73)	0.796	4(100)	0.796	27(61.4)	0.315	6(50)	0.050	25(73.5)	0.895
Mother	8(21.6)		0(0)		15(34.1)		4(33.3)		8(23.5)	
Father, grandfather, uncle	2(5.4)		0(0)		2(4.5)		2(16.7)		1(2.9)	
Mother's level of schooling										
Up to high school	12(41.4)	0.218	1(33.3)	0.218	20(50)	0.148	7(58.3)	0.657	12(48)	0.865
High school	12(41.4)		0(0)		7(17.5)		2(16.7)		8(32)	
High school+	5(17.2)		2(66.7)		13(32.5)		3(25)		5(20)	
Father's level of schooling										
Up to high school	11(47.8)	0.272	1(33.3)	0.272	17(53.1)	0.506	5(55.6)	0.670	12(60)	0.768
High school	4(17.4)		2(66.7)		10(31.3)		3(33.3)		4(20)	
High school+	8(34.8)		0(0)		5(15.6)		1(11.1)		4(20)	
Mother's age range (yrs)										
<30	1(2.9)	0.212	1(25)	0.212	4(9.5)	0.905	0(0)	0.044	3(9.7)	0.878
30 - 40	20(57.1)		1(25)		23(54.8)		4(33.3)		18(58.1)	
40+	14(40)		2(50)		15(35.7)		8(66.7)		10(32.3)	
Father's age range (yrs)										
<30	0(0)	**0.034**	1(25)	**0.034**	1(2.8)	0.940	0(0)	0.530	0(0)	0.455
30 - 40	9(26.5)		0(0)		15(41.7)		3(30)		13(50)	
40+	25(73.5)		3(75)		20(55.6)		7(70)		13(50)	

** Students who responded / answered affirmatively to these sources of SRH information;* χ^2 test,95%

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Multi-Dimensional Rajan Transform

By K. Thiagarajan, Manish Prateek & Ethirajan Govindarajan
University of Petroleum and Energy Studies

Abstract- In this paper, we describe the formulation of a novel transform called Multi-Dimensional Rajan Transform, which is an extension of Rajan Transform. Basically, Rajan Transform operates on a number sequence, whose length is a power of two. It transforms any sequence of arbitrary numbers into a sequence of interrelated numbers. As regards 2D Rajan Transform, there are two methods to implement it: (i) Row- Column method and (ii) Column-Row method. The 2D Rajan Transform obtained using the first method need not be the same as that obtained using second method. Similarly, one can implement 3-D Rajan Transform using the following approaches: (i) Row-Column-Depth approach, (ii) Row-Depth- Column approach, (iii) Column-Row-Depth approach, (iv) Column-Depth-Row approach, (v) Depth-Row-Column approach and (vi) Depth-Column-Row approach. This paper explains these approaches to implement two and three dimensional Rajan Transforms.

Keywords: *discrete transforms, rajan transform, permutation invariant systems, homomorphic transforms.*

GJCST-G Classification: *F.2.1*

Strictly as per the compliance and regulations of:

Multi-Dimensional Rajan Transform

K. Thiagarajan [α], Manish Prateek [σ] & Ethirajan Govindarajan [ρ]

Abstract- In this paper, we describe the formulation of a novel transform called Multi-Dimensional Rajan Transform, which is an extension of Rajan Transform. Basically, Rajan Transform operates on a number sequence, whose length is a power of two. It transforms any sequence of arbitrary numbers into a sequence of interrelated numbers. As regards 2D Rajan Transform, there are two methods to implement it: (i) Row-Column method and (ii) Column-Row method. The 2D Rajan Transform obtained using the first method need not be the same as that obtained using second method. Similarly, one can implement 3-D Rajan Transform using the following approaches: (i) Row-Column-Depth approach, (ii) Row-Depth-Column approach, (iii) Column-Row-Depth approach, (iv) Column-Depth-Row approach, (v) Depth-Row-Column approach and (vi) Depth-Column-Row approach. This paper explains these approaches to implement two and three dimensional Rajan Transforms.

Keywords: discrete transforms, rajan transform, permutation invariant systems, homomorphic transforms.

I. Introduction

Rajan transform essentially operates on a number sequence, whose length is a power of two. It transforms any sequence of arbitrary numbers into a sequence of interrelated numbers. The resulting sequence is called 'Rajan Spectrum'. More precisely,Rajan Transform is a homomorphic map that yields the same Rajan Spectrum for an input sequence and all of its permuted versions. The definition and various outcomes of One-Dimensional Rajan Transform (1D-RT) are extended to multi-dimensional case. One-dimensional Rajan Transform is briefly explained on a need to have basis.

Definition of Rajan Transform

Rajan Transform is essentially a fast algorithm developed on the lines of Decimation-In-Frequency Fast Fourier Transform algorithms, but it is functionally different from the DIF-FFT algorithm. Given a number sequence x(n) of length N, which is a power of 2, first it is divided into the first half and the second half each consisting of (N/2) points so that the following holds good.

$$g(i) = x(i) + x(i+N/2) \; ; \; 0 \le j \le N/2; \; 0 \le i \le N/2$$

$$h(j) = |x(i) - x(i-N/2)| \; ; \; 0 \le j \le N/2; \; 0 \le i \le N/2$$

Now each (N/2) point segment is further divided into two halves each consisting of N/4 points so that the following holds good.

$$g1(k) = g(i) + g(j+(N/4)); \; 0 \le k \le (N/4); \; 0 \le j \le (N/4)$$

$$g2(k) = |g(i) - g(i-(N/4)| \; ; \; 0 \le k \le (N/4); \; (N/4) \le j \le (N/2)$$

$$h1(k) = h(j) + h(j+(N/4)); \; 0 \le k \le (N/4); \; 0 \le j \le (N/4)$$

$$h2(k) = |h(j) - h(j-N/4)| \; ; \; 0 \le k \le (N/4); \; 0 \le j \le (N/4)$$

This process is continued until no more division is possible. The total number of stages thus turns out to be $\log_2 N$. Let us denote the sum and difference operators respectively as '+' and '~'. Then the signal flow graph for the Rajan Transform of a number sequence of length 16 would be of the form shown in Fig. 1. If x(n) is a number sequence of length $N=2^k$; $k>0$, then its Rajan Transform(RT) is denoted as X(k). RT is applicable to any number sequence and it induces an isomorphism in a class of sequence, that is, it maps a domain set consisting of the cyclic and dyadic permutations of a sequence on to a range set consisting of sequence of the form X(k)E(r) where X(k) denotes the permutation invariant RT and E(r) an encryption code corresponding to an element in the domain set. This map is a one-to-one and on to correspondence and an inverse map also exists. Hence, it is viewed as a transform. Fig. 1 shows a functional block diagram of a 16-point Rajan Transform algorithm.

It is to be noted that the map $x(n) \leftrightarrow X(k)E(r)$ is an isomorphic map, and the map $x(n) \rightarrow X(k)$ is a homomorphic map. The inverse function is called Inverse Rajan Transform and is applicable to cases where Rajan Transform is considered as an isomorphic function. Homomorphic functions do not have inverse functions. The operation of Inverse Rajan Transform is not explained here in this paper for lack of space and for its irrelevance in the formulation of multi-dimensional Rajan Transforms. Apart from multi-dimensional Rajan Transforms, which are conceptual extensions of one-dimensional Rajan Transform, one can as well develop notions like "Set-Theoretic Rajan Transform" which are higher order algebraic tools that work on sequences of sets, functions and relations. These formulations are not in the scope of this paper and thus they are not presented.

Author α: Professor, Department of Mathematics, K. Ramakrishnan College of Technology, Samayapuram, Trichy, Tamil Nadu, India.
e-mail: vidhyamannan@yahoo.com
Author σ: Professor and Dean, School of Computer Science, University of Petroleum and Energy Studies, Dehradun, Uttarakhand, India.
e-mail: mprateek@ddn.upes.ac.in
Author ρ: Adjunct Professor, Department of Cybernetics, School of Computer Science, UPES, Dehradun, Uttarakhand, India.
e-mail: dr.rajaneg@gmail.com

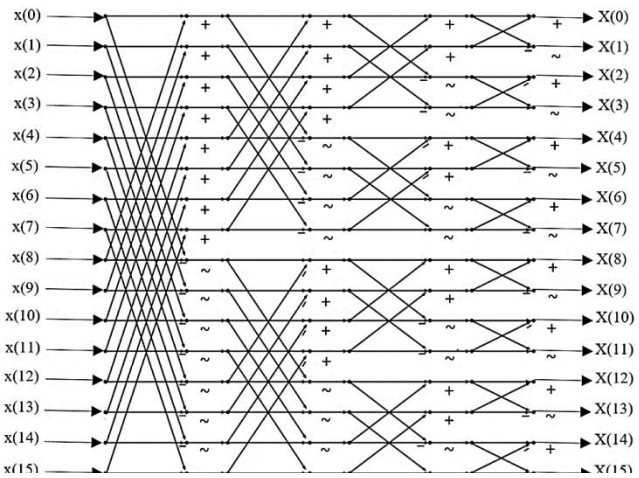


Fig. 1: Signal flow graph of Rajan Transform

II. Two Dimensional Rajan Transform and its Implementation

As outlined earlier, one can implement two-dimensional Rajan Transformin two different ways: (i) Row-Column method and (ii) Column-Row method. As stated previously, 2D Rajan Spectrum obtained using first method need not be the same as the spectrum obtained using second method. This could be verified with the help of an example. Consider a two dimensional array A = [x(m,n)].

$$A = [x(m,n)] = \begin{matrix} 0\,0\,0\,0 \\ 1\,1\,1\,0 \\ 0\,1\,0\,0 \\ 0\,1\,0\,0 \end{matrix}$$

2D-RT obtained using Row-Colum method

The RT spectra of the four rows of the array A are the four rows given in the array $[X_r(g,h)]$

$$[X_r(g,h)] = \begin{matrix} 0\,0\,0\,0 \\ 3\,1\,1\,0 \\ 1\,1\,1\,1 \\ 1\,1\,1\,1 \end{matrix}$$

Next, the RT spectra of the four columns in the array $[X_r(g,h)]$ are given in the columns of the array $[X_{r,c}(k_1,k_2)]$, which is the 2D-RT of the given array A.

$$[X_{r,c}(k_1,k_2)] = \begin{matrix} 5\,3\,3\,3 \\ 3\,1\,1\,1 \\ 3\,1\,1\,1 \\ 1\,1\,1\,1 \end{matrix}$$

2D-RT obtained using Column-Row method

The RT spectra of the four columns of the array A are the four columns given in the array $[X_c(g,h)]$

$$[X_c(g,h)] = \begin{matrix} 1\,3\,1\,0 \\ 1\,1\,1\,0 \\ 1\,1\,1\,0 \\ 1\,1\,1\,0 \end{matrix}$$

Next, the RT spectra of the four rows in the array $[X_c(g,h)]$ are given in the rows of the array $[X_{c,r}(k_1,k_2)]$, which is the 2D-RT of the given array A.

$$[X_{c,r}(k_1,k_2)] = \begin{matrix} 5\,1\,3\,3 \\ 3\,1\,1\,1 \\ 3\,1\,1\,1 \\ 3\,1\,1\,1 \end{matrix}$$

With reference to the example presented above, it is proved that $[X_{r,c}(k_1,k_2)] \neq [X_{c,r}(k_1,k_2)]$ in this case. However, one can verify that $[X_{r,c}(K_1,k_2)] = [X_{c,r}(k_1,k_2)]$ for symmetric arrays. In order to do this, let us consider Hilbert matrix H_4 and obtain 2D-RT spectra using both methods.

$$H_4 = [x(m,n)] = \begin{matrix} 1\,2\,3\,4 \\ 2\,3\,4\,5 \\ 3\,4\,5\,6 \\ 4\,5\,6\,7 \end{matrix}$$

The 2D-RT spectra of H_4 obtained using Row-Column method is $X_{r,c}(k_1,k_2)$ and it is shown below.

$$[X_{r,c}(k_1,k_2)] = \begin{matrix} 64\,08\,16\,00 \\ 08\,00\,00\,00 \\ 16\,00\,00\,00 \\ 00\,00\,00\,00 \end{matrix}$$

The 2D-RT spectra of H_4 obtained using Column-Row method is $X_{c,r}(k_1,k_2)$ and it is shown below.

$$[X_{c,r}(k_1,k_2)] = \begin{matrix} 64\,08\,16\,00 \\ 08\,00\,00\,00 \\ 16\,00\,00\,00 \\ 00\,00\,00\,00 \end{matrix}$$

In this case of symmetric matrix $[X_{r,c}(k_1,k_2)] = [X_{c,r}(K_1,k_2)]$.

2D-RT Translation invariance property

Consider the two-dimensional array A showing aT like pattern.

$$A = [x(m,n)] = \begin{matrix} 0\,0\,0\,0 \\ 1\,1\,1\,0 \\ 0\,1\,0\,0 \\ 0\,1\,0\,0 \end{matrix}$$

B is the translated version of A.

$$B = [x_t(m,n)] = \begin{matrix} 0\,1\,1\,1 \\ 0\,0\,1\,0 \\ 0\,0\,1\,0 \\ 0\,0\,0\,0 \end{matrix}$$

One can verify that $[X_{c,r}(K_1,k_2)]$ for both arrays A and B remain the same. Similarly, one can verify that $[X_{r,c}(k_1,k_2)]$ remain the same for both arrays A and B. This amounts to saying that 2D-Rajan Transform is essentially a translation invariant function, which could be effectively used in pattern recognition.

III. Three-Dimensional Rajan Transform

The definition and various properties associated with two dimensional RT is extended to the three-dimensional case also. Especially, the basic methods for implementing2D Rajan Transform like Row-Column method and Column-Row method could further be generalized to implement 3D Rajan Transform. One can implement 3-D Rajan Transform using any one of the following six methods: (i) Row-Column-Depth method, (ii) Row-Depth-Column method, (iii) Column-Row-Depth method, (iv) Column-Depth-Row method, (v) Depth-Row-Column method and (vi) Depth-Column-Row method. Let us consider the three dimensional array of matrix size 4x4x4 as shown in Fig. 2.

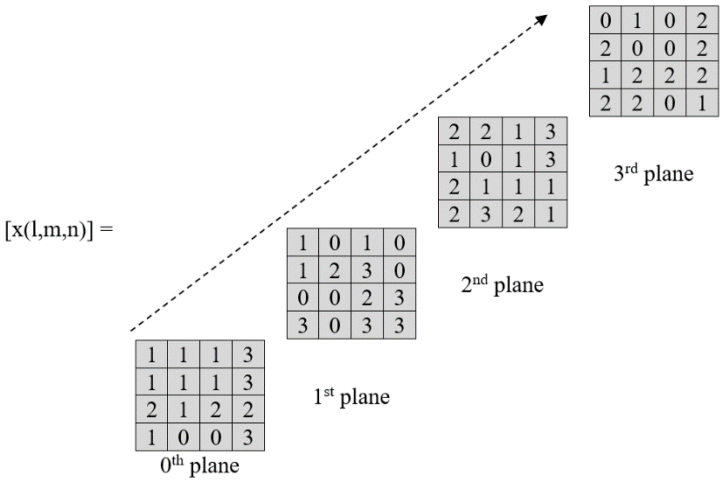


Fig. 2: Sample three dimensional array

The above 3-D matrix is represented in a linear array of 2-D planes for easy understanding.

$$x(l, m, n) = \left[\begin{array}{cccc|cccc|cccc|cccc} 1&1&1&3 & 1&0&1&0 & 2&2&1&3 & 0&1&0&2 \\ 1&1&1&3 & 1&2&3&0 & 1&0&1&3 & 2&0&0&2 \\ 2&1&2&2 & 0&0&2&3 & 2&1&1&1 & 1&2&2&2 \\ 1&0&0&3 & 3&0&3&3 & 2&3&2&1 & 2&2&0&1 \end{array}\right]$$

0^{th} plane 1^{st} plane 2^{nd} plane 3^{rd} plane

3D-RT using Row-Column-Depth (RCD) Approach

The 1D-RT of the four rows of the 0^{th} plane of the matrix X are {1,1,1,3}→{6,2,2,2}, {1,1,1,3}→{6,2,2,2}, {2,1,2,2}→{7,1,1,1}, {1,0,0,3}→{4,2,4,2}. The 1D-RT of the four rows of the 1^{st} plane are {1,0,1,0}→{2,2,0,0}, {1,2,3,0}→{6,2,4,0}, {0,0,2,3}→{5,1,5,1}, {3,0,3,3}→{9,3,3,3}. The 1D-RT of the four rows of the 2^{nd} plane are {2,2,1,0}→{8,2,2,0}, {1,0,1,3}→{5,1,3,3}, {2,1,1,1}→{5,1,1,1}, {2,3,2,1}→{8,0,2,2}. The 1D-RT of the final plane of four rows are {0,1,0,2}→{3,3,1,1}, {2,0,0,2}→{4,0,4,0}, {1,2,2,2}→{7,1,1,1}, {2,2,0,1}→{5,1,3,1}.

Now the 3D array of the Rajan Transform computed row wise is given by

$$X_r(k_1,k_2,k_3) = \left[\begin{array}{cccc|cccc|cccc|cccc} 6&2&2&2 & 2&2&0&0 & 8&2&2&0 & 3&3&1&1 \\ 6&2&2&2 & 6&2&4&0 & 5&1&3&3 & 4&0&4&0 \\ 7&1&1&1 & 5&1&5&1 & 5&1&1&1 & 7&1&1&1 \\ 4&2&4&2 & 9&3&3&3 & 8&0&2&2 & 5&1&3&1 \end{array}\right]$$

0^{th} plane 1^{st} plane 2^{nd} plane 3^{rd} plane

The 1D-RT of the four columns of the 0^{th} plane of the matrix $X_r(k_1,k_2,k_3)$ are {6,6,7,4}→{23,3,3,1}, {2,2,1,2}→{7,1,1,1}, {2,2,1,4}→{9,3,3,1}, {2,2,1,2}→{7,1,1,1}. The 1D-RT of the four columns of the 1^{st} plane are {2,6,5,9}→{22,8,6,0}, {2,2,1,3}→{8,2,2,0}, {0,4,5,3}→{12,2,6,4}, {0,0,1,3}→{4,2,4,2}. The 1D-RT of the four columns of the 2^{nd} plane are {8,5,5,8}→{26,0,6,0}, {2,1,1,0}→{4,2,2,0}, {2,3,1,2}→{8,2,2,0}, {0,3,1,2}→{6,4,2,0}. The 1D-RTs of the final plane of four columns are {3,4,7,5}→{19,1,5,3}, {3,0,1,1}→{5,3,3,1}, {1,4,1,3}→{9,5,1,1}, {1,0,1,1}→{3,1,1,1}.Now the 3D array of the Rajan Transform Row-Column wise is given by

$$X_{r,c}(k_1,k_2,k_3) = \begin{bmatrix} 23 & 7 & 9 & 7 & 22 & 8 & 12 & 4 & 26 & 4 & 8 & 6 & 19 & 5 & 9 & 3 \\ 3 & 1 & 3 & 1 & 8 & 2 & 2 & 2 & 0 & 2 & 2 & 4 & 1 & 3 & 5 & 1 \\ 3 & 1 & 3 & 1 & 6 & 2 & 6 & 4 & 6 & 2 & 2 & 2 & 5 & 3 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 0 & 4 & 2 & 0 & 0 & 0 & 0 & 3 & 1 & 1 & 1 \end{bmatrix}$$
$$0^{th}\text{ plane} \qquad 1^{st}\text{ plane} \qquad 2^{nd}\text{ plane} \qquad 3^{rd}\text{ plane}$$

The 1D-RT of the depth wise of four corresponding elements in four planes of the matrix $X_{r,c}(k_1,k_2,k_3)$, (RT can compute starting with any element in 0^{th} plane, in this example the RTs computed starting with row wise for easy understanding) are {23,22, 26,19}→{90,8,6,0}, {7,8,4,5}→{24,2,6,0}, {9,12,8,9}→{38,4,4,2}, {7,4,6,3}→{20,6,2,0}, {3,8,0,1}→{22,6,10,4}, {1,2,2,3}→{8,2,2,0}, {3,2,2,5}→{12,2,4,2}, {1,2,4,1}→{8,2,4,2}, {3,6,6,5}→{20,2,4,2}, {1,2,2,3}→{8,2,2,0}, {3,6,2,1}→{12,2,6,4}, {1,4,2,1}→{8,2,4,2}, {1,0,0,3}→{4,2,4,2}, {1,0,0,1}→{2,0,2,0}, {1,4,0,1}→{6,4,4,2} and {1,2,0,1}→{4,2,2,0}. Now the 3D array of the Rajan Transform Row-Column-Depth wise is given by

$$X_{r,c,d}(k_1,k_2,k_3) = \begin{bmatrix} 90 & 24 & 38 & 20 & 8 & 2 & 4 & 6 & 6 & 6 & 4 & 2 & 0 & 0 & 2 & 0 \\ 12 & 8 & 12 & 8 & 6 & 2 & 2 & 2 & 10 & 2 & 4 & 4 & 4 & 0 & 2 & 2 \\ 20 & 8 & 12 & 8 & 2 & 2 & 2 & 2 & 4 & 2 & 6 & 4 & 2 & 0 & 4 & 2 \\ 4 & 2 & 6 & 4 & 2 & 0 & 4 & 2 & 4 & 2 & 4 & 2 & 2 & 0 & 2 & 0 \end{bmatrix}$$
$$0^{th}\text{ plane} \qquad 1^{st}\text{ plane} \qquad 2^{nd}\text{ plane} \qquad 3^{rd}\text{ plane}$$

3D-RT using Row-Depth-Column (RDC) Approach
The 3D matrix using Row-Depth-Column Rajan Transform is

$$X_{r,d,c}(k_1,k_2,k_3) = \begin{bmatrix} 90 & 24 & 38 & 20 & 18 & 6 & 12 & 12 & 24 & 12 & 18 & 12 & 8 & 0 & 10 & 4 \\ 4 & 2 & 12 & 6 & 2 & 2 & 0 & 4 & 4 & 4 & 2 & 0 & 4 & 0 & 2 & 0 \\ 10 & 6 & 4 & 4 & 10 & 2 & 4 & 4 & 8 & 4 & 2 & 4 & 4 & 0 & 2 & 4 \\ 0 & 4 & 2 & 2 & 2 & 2 & 0 & 4 & 4 & 4 & 2 & 0 & 0 & 0 & 2 & 0 \end{bmatrix}$$
$$0^{th}\text{ plane} \qquad 1^{st}\text{ plane} \qquad 2^{nd}\text{ plane} \qquad 3^{rd}\text{ plane}$$

Note that $X_{r,c,d}(k_1,k_2,k_3) \neq X_{r,d,c}(k_1,k_2,k_3)$, but the CPI is same as 90.
3D-RT using Column-Row-Depth (CRD) Approach
The 3D matrix using Column-Row-DepthRajan Transform is

$$X_{c,r,d}(k_1,k_2,k_3) = \begin{bmatrix} 90 & 18 & 26 & 8 & 8 & 4 & 0 & 6 & 6 & 8 & 8 & 8 & 0 & 2 & 2 & 6 \\ 24 & 12 & 4 & 4 & 6 & 2 & 2 & 2 & 6 & 2 & 2 & 2 & 4 & 0 & 0 & 0 \\ 34 & 12 & 10 & 4 & 4 & 2 & 8 & 2 & 10 & 8 & 4 & 2 & 0 & 2 & 2 & 0 \\ 16 & 2 & 6 & 6 & 2 & 0 & 0 & 0 & 2 & 2 & 2 & 2 & 0 & 0 & 0 & 0 \end{bmatrix}$$
$$0^{th}\text{ plane} \qquad 1^{st}\text{ plane} \qquad 2^{nd}\text{ plane} \qquad 3^{rd}\text{ plane}$$

Note that $X_{c,r,d}(k_1,k_2,k_3)$ is difference from others, but the CPI is same as 90.
3D-RT using Column-Depth-Row (CDR) Approach
The 3D matrix using Column-Depth-RowRajan Transform is

$$X_{c,d,r}(k_1,k_2,k_3) = \begin{bmatrix} 90 & 6 & 18 & 14 & 12 & 4 & 4 & 4 & 20 & 0 & 8 & 4 & 11 & 7 & 7 & 3 \\ 20 & 16 & 8 & 4 & 6 & 2 & 2 & 2 & 8 & 0 & 0 & 0 & 2 & 2 & 2 & 2 \\ 34 & 10 & 2 & 2 & 4 & 0 & 4 & 0 & 16 & 8 & 4 & 4 & 6 & 2 & 2 & 2 \\ 16 & 0 & 4 & 4 & 2 & 2 & 2 & 2 & 6 & 2 & 2 & 2 & 0 & 0 & 0 & 0 \end{bmatrix}$$
$$0^{th}\text{ plane} \qquad 1^{st}\text{ plane} \qquad 2^{nd}\text{ plane} \qquad 3^{rd}\text{ plane}$$

Note that $X_{c,r,d}(k_1,k_2,k_3) \neq X_{c,d,r}(k_1,k_2,k_3)$, but the CPI is same as 90.
3D-RT using Depth-Row-Column (DRC) Approach
The 3D matrix using Depth-Row-ColumnRajan Transform is

$$X_{d,r,c}(k_1,k_2,k_3) = \begin{bmatrix} 90 & 6 & 22 & 10 & 26 & 10 & 12 & 4 & 28 & 6 & 8 & 4 & 16 & 2 & 10 & 4 \\ 4 & 4 & 0 & 0 & 4 & 0 & 2 & 2 & 2 & 0 & 6 & 2 & 2 & 0 & 0 & 2 \\ 10 & 6 & 2 & 6 & 6 & 2 & 2 & 4 & 8 & 2 & 2 & 2 & 6 & 2 & 2 & 2 \\ 0 & 4 & 0 & 4 & 0 & 0 & 0 & 2 & 6 & 0 & 0 & 0 & 4 & 0 & 0 & 0 \end{bmatrix}$$
$$0^{th}\text{ plane} \qquad 1^{st}\text{ plane} \qquad 2^{nd}\text{ plane} \qquad 3^{rd}\text{ plane}$$

Note that $X_{d,r,c}(k_1,k_2,k_3)$ is difference from others, but the CPI is same as 90.
3D-RT using Depth-Column-Row (DCR) Approach
The 3D matrix using Depth-Column-RowRajan Transform is

$$X_{d,\,c,\,r}(k_1,k_2,k_3) = \left[\begin{array}{cccc|cccc|cccc|cccc} 90 & 6 & 18 & 14 & 26 & 2 & 10 & 2 & 38 & 6 & 6 & 2 & 16 & 0 & 4 & 4 \\ 4 & 4 & 4 & 4 & 4 & 0 & 4 & 0 & 12 & 0 & 8 & 4 & 2 & 2 & 2 & 2 \\ 10 & 6 & 2 & 2 & 10 & 6 & 6 & 2 & 8 & 0 & 0 & 0 & 10 & 2 & 2 & 2 \\ 8 & 4 & 4 & 0 & 4 & 4 & 0 & 0 & 6 & 2 & 2 & 2 & 4 & 0 & 4 & 0 \end{array}\right]$$

0^{th} plane 1^{st} plane 2^{nd} plane 3^{rd} plane

Note that $X_{d,r,c}(k_1,k2,k3) \neq X_{d,c,r}(k_1,k_2,k_3)$, but the CPI is same as 90.

3D-RT Translation invariance property

Let us consider a solid 3-D object of 3x3x3 size placed in top left corner of the lattice grid as shown in Fig. 3. Now Rajan transform is applied to this 8x8x8 matrix Row-wise (ref Fig. 4), Column-wise (ref Fig. 5) and Depth-wise (ref Fig. 6). The resultant 3-D matrix is shown in Fig. 6. Next, the 3-D object subimage is translated in the 8x8x8 matrix as shown in Fig. 7. Subsequently RT is applied to this 8x8x8 translated matrix Row-wise (ref Fig. 8), Column-wise (ref Fig. 9) and Depth-wise (ref Fig. 10) and resultant matrix is shown in Fig. 10. Fig. 11 shows translation invariance property demonstrated by 3D-RT

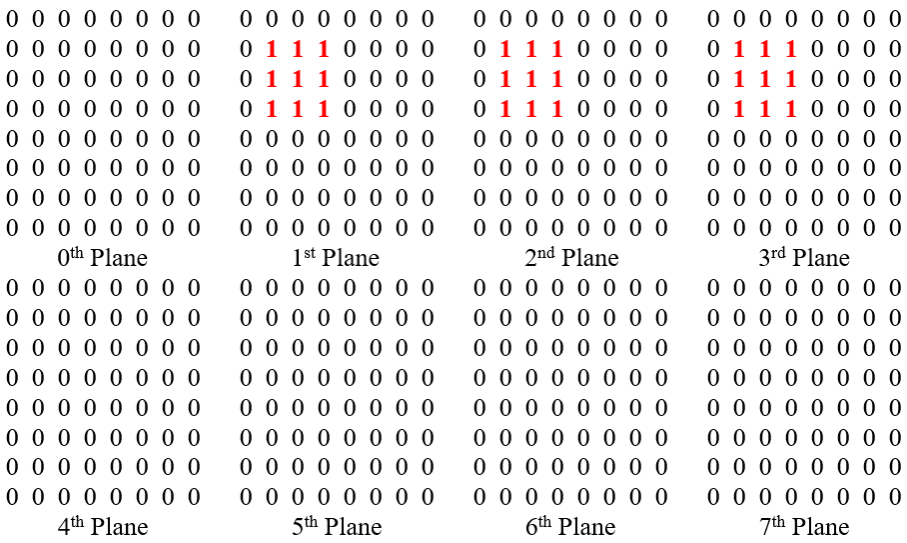


Fig. 3: 3-D Object of size 3x3x3 with in the 8x8x8 grid

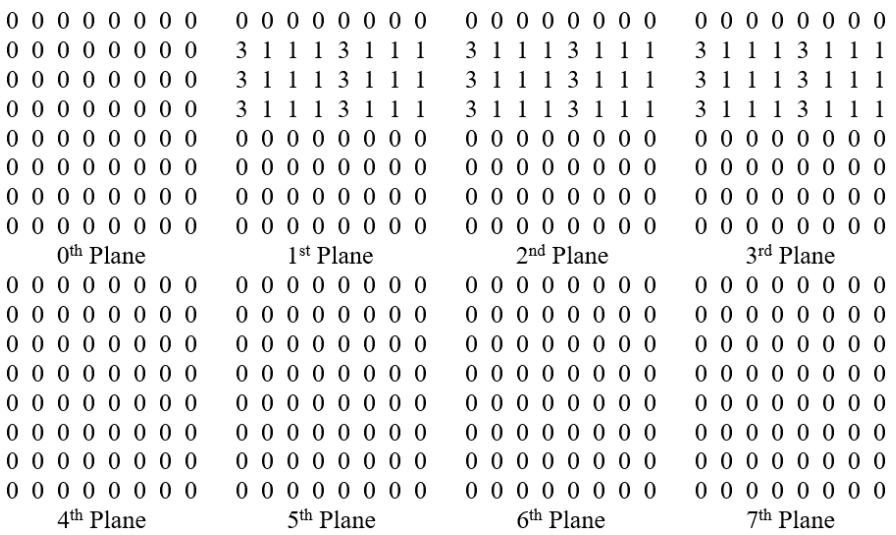


Fig. 4: Resultant 3-D array after applying row wise RT to Fig. 3

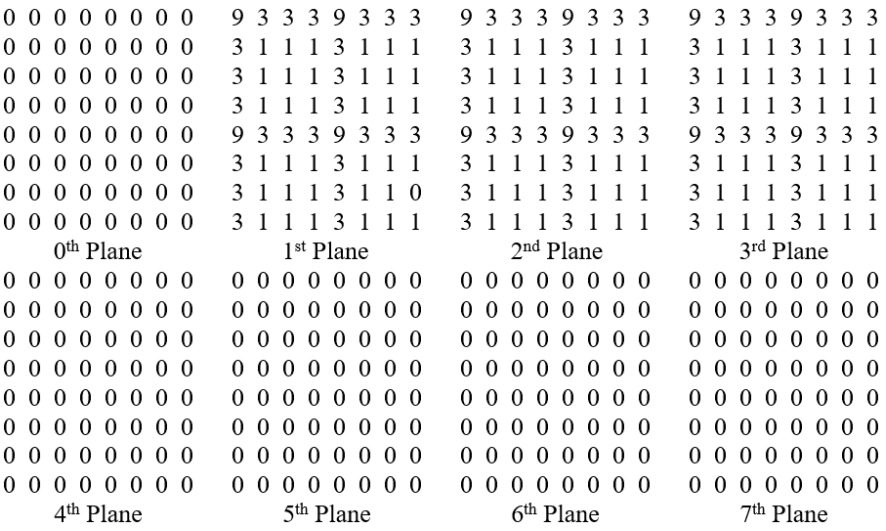


Fig. 5: Resultant 3-D array after applying column wise RT to Fig. 4

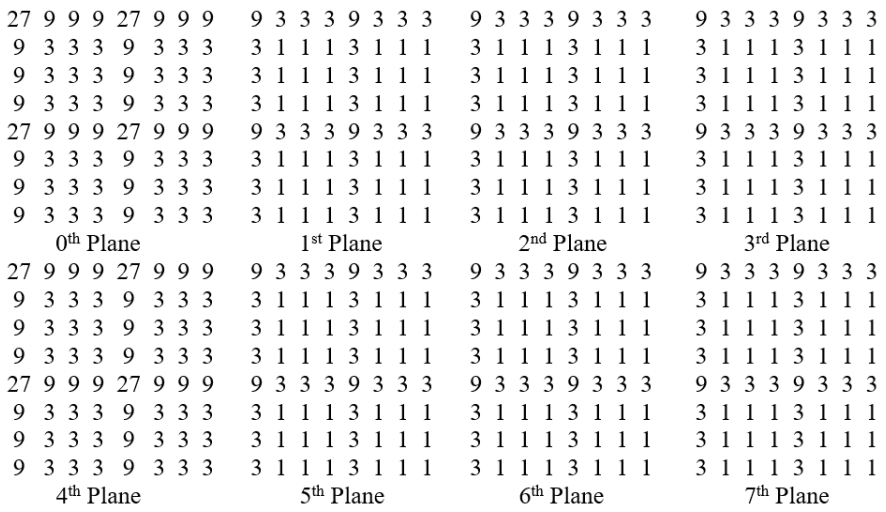


Fig. 6: Resultant 3-D array after applying depth wise RT to Fig. 5

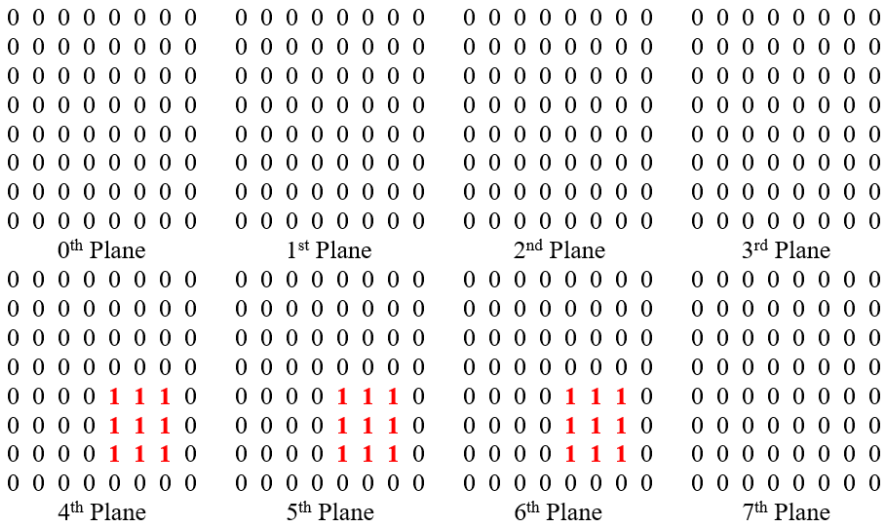


Fig. 7: 3-D Object is translated with in the 8x8x8 grid

0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0th Plane	1st Plane	2nd Plane	3rd Plane
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
4th Plane	5th Plane	6th Plane	7th Plane

Fig. 8: Resultant 3-D array after applying row wise RT to Fig. 7

0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0th Plane	1st Plane	2nd Plane	3rd Plane
9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	0 0 0 0 0 0 0 0
4th Plane	5th Plane	6th Plane	7th Plane

Fig. 9: Resultant 3-D array after applying column wise RT to Fig. 8

27 9 9 9 27 9 9 9	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
27 9 9 9 27 9 9 9	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
0th Plane	1st Plane	2nd Plane	3rd Plane
27 9 9 9 27 9 9 9	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
27 9 9 9 27 9 9 9	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3	9 3 3 3 9 3 3 3
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
9 3 3 3 9 3 3 3	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1	3 1 1 1 3 1 1 1
4th Plane	5th Plane	6th Plane	7th Plane

Fig. 10: Resultant 3-D array after applying depth wise RT to Fig. 9

Fig. 11 given in the next page, shows that 3D-RT of the original 3-D matrix (Fig. 6) and the 3D-RT of the translated 3-D matrix (Fig. 10) are the same. So, the invariance property of 3D-RT could be seen to be applicable to 3D images also. This amounts to saying that 1D-RT, 2D-RT and 3D-RT could be reliably used in real world applications.

Cyclic Shift Invariance Property

Consider the sequence x(n)=3,8,5,6,0,2,9,6. Now, seven more cyclic shifted versions such as $x_{c1}(n)$=6,3,8,5,6,0,2,9; $x_{c2}(n)$=9,6,3,8,5,6,0,2; $x_{c3}(n)$=2,9,6,3,8,5,6,0; $x_{c4}(n)$=0,2,9,6,3,8,5,6; $x_{c5}(n)$=6,0,2,9,6,3,8,5; $x_{c6}(n)$=5,6,0,2,9,6,3,8 and $x_{c7}(n)$=8,5,6,0,2,9,6,3 could be generated from x(n). All the eight sequences have the same X(k)=39,5,13,9,13,1,7,5, meaning Rajan Transform of a given sequence of length N would remain invariant for N cyclically permuted sequences. This property is satisfied by higher order RT, that is, 2D-RT and 3D-RT also.

Graphical Inverse Invariance Property

Consider x(n)=3,8,5,6,0,2,9,6. Its graphical inverse is $x^{-1}(n)$=6,9,2,0,6,5,8,3. Now, one can generate seven more cyclic shifted versions such as $x_{c1}^{-1}(n)$=3,6,9,2,0,6,5,8; $x_{c2}^{-1}(n)$=8,3,6,9,2,0,6,5; $x_{c3}^{-1}(n)$=5,8,3,6,9,2,0,6, $x_{c4}^{-1}(n)$=6,5,8,3,6,9,2,0; $x_{c5}^{-1}(n)$=0,6,5,8,3,6,9,2; $x_{c6}^{-1}(n)$=2,0,6,5,8,3,6,9 and$x_{c7}^{-1}(n)$=9,2,0,6,5,8,3,6. One can easily verify that all these eight sequences have the same X(k)=39,5,13, 9,13,1,7,5, meaning Rajan Transform of a given sequence of length N would remain invariant for N graphically inverted sequence and its cyclically permuted sequences. This property is satisfied by higher order RT, that is, 2D-RT and 3D-RT also.

Dyadic Shift Invariance Property

Consider x(n)=3,8,5,6,0,2,9,6 and transpose its first half with the second half. The resulting sequence $Td^{(2)}[x(n)]$=0,2,9,6,3,8,5,6 is the 2-block dyadic shifted version of x(n). The symbol $Td^{(2)}$ denotes the 2-block dyadic shift operator. In the same manner, one would obtain $Td^{(4)}[Td^{(2)}[x(n)]]$=9,6,0,2,5,6,3,8 and $Td^{(8)}[Td^{(4)}[Td^{(2)}[x(n)]]]$=6,9,2,0,6,5,8,3. Note that the graphical inverse of x(n) is $x^{-1}(n)$=(6,9,2,0,6,5,8,3) and it is the same as $Td^{(8)}[Td^{(4)}[Td^{(2)}[x(n)]]]$=6,9,2,0,6,5,8,3. One can easily verify that all these dyadic shifted sequences have the same X(k), that is, the sequence 39,5,13,9,13,7,5. There is yet another way of dyadic shifting the input sequence x(n) to $Td^{(2)}[Td^{(4)}[Td^{(8)}[x(n)]]]$. Consider the sequence x(n)=3,8,5,6,0,2,9,6 and one can obtain $Td^{(8)}[x(n)]$=8,3,6,5,2,0,6,9; $Td^{(4)}[Td^{(8)}[x(n)]]$=6,5,8,3,6,9, 2,0 and $Td^{(2)}[Td^{(4)}[Td^{(8)}[x(n)]]]$=6,9,2,0,6,5,8,3 as dyadic shifts. Note that $Td^{(2)}[Td^{(4)}[Td^{(8)}[x(n)]]] = Td^{(8)}[Td^{(4)}[Td^{(2)}[x(n)]]]$. This property is satisfied by higher order RT, that is, 2D-RT and 3D-RT also.

Dual Class Invariance Property

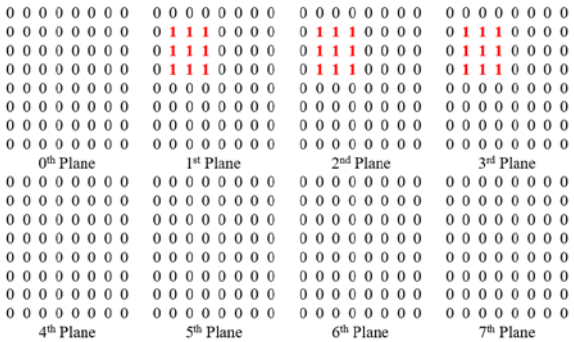
Given a sequence x(n), one can construct another sequence y(n) consisting of at least one number which is not present in x(n) such that X(k)=Y(k). In such a case, y(n) is called the 'dual' of x(n). Consider two sequences x(n)=2,4,2,2 and y(n)=3,1,3,3. Then X(k)=Y(k)=10,2,2,2. An underlying theorem to characterize a sequence of length $N=2^n$ to pair up with a dual sequence is "*A sequence is said to have a dual if and only if its CPI is an even number and is divisible by N/2*". This theorem advocates a necessary condition but not a sufficient condition. For example, consider the sequence x(n)=6,8,2,0. This indeed satisfies the theorem. That is, its CPI is 16 and the value of CPI/(N/2) is 8. Now its dual is computed as y(n)=2,0,6,8, which is not a dual of x(n) as per the definition. In such cases, they are called 'self dual' pairs. Some of the properties of dual sequences are: (i) if y(n) is a dual of x(n), then x(n) is also called the dual of y(n). Hence the pair<x(n),y(n)> is called 'dual pair'; (ii) dual of a sequence, say y(n) will necessarily exhibit geometric symmetry together with the original sequence x(n); (iii) each dual pair has a value called 'Differential Mean' (DM), which is equal to $(|x(i)\sim y(i)|)/2; 0\leq i\leq(N-1)$ about which the dual sequences are 'flip' symmetric. DM could be a real number. This property is satisfied by higher order RT, that is, 2D-RT and 3D-RT also.

Scalar Property

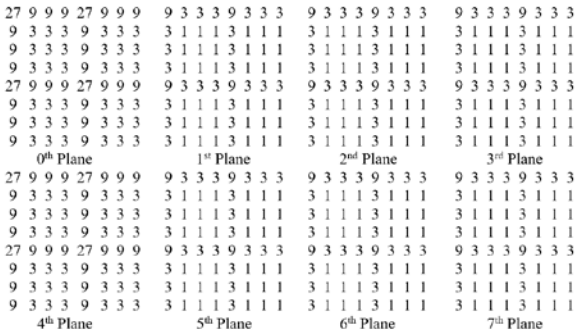
Let x(n) be a number sequence and λ be a scalar. Then the RT of λx(n) will be λX(k), where X(k) is the RT of x(n). For example, let us consider a sequence x(n)=1,3,1,2 and a scalar λ of value 2. Now the RT X(k) of x(n) is 7,3,1,1. RT of λx(n)=2,6,2,4 is 14,6,2,2 which is nothing but λX(k).This property is satisfied by higher order RT, that is, 2D-RT and 3D-RT also.

Linearity Property

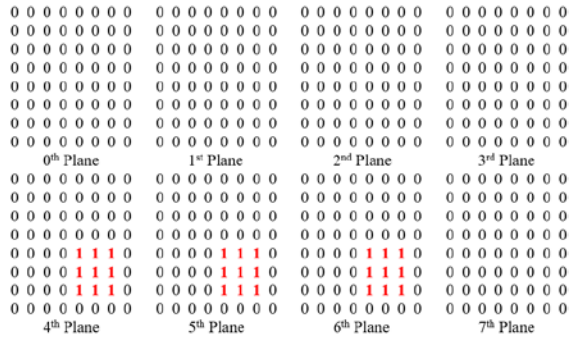
In general, RT does not satisfy the linearity property for all sequences. It was observed that for a pair x(n) and y(n) which are number sequences either in the increasing order or in the decreasing order, the linearity property works. That is, for λx(n)+my(n) where λ and m are scalars and x(n) and y(n) are two number sequences either in the increasing or decreasing order, the RT will be λX(k)+mY(k), where X(k) and Y(k) are respectively the RTs of x(n) and y(n). This property is satisfied by higher order RT, that is, 2D-RT and 3D-RT also.



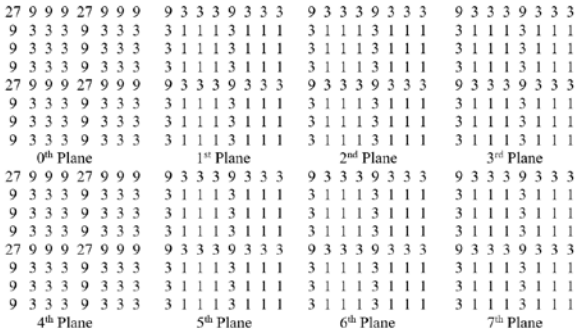
3-D Object of size 3x3x3 with in the 8x8x8 grid



Corresponding 3D Rajan Transform as shown in Fig. 6



3-D Object is translated with in the 8x8x8 grid



Corresponding3D Rajan Transform as shown in Fig. 10

Fig. 11: Translation invariance property demonstrated by 3D-RT

IV. Conclusions

This paper introduces the formulation of a novel transform called Multi-Dimensional Rajan Transform, which is an extension of One-Dimensional Rajan Transform (1D-RT). 2D and 3D Rajan Transforms are presented and the translation invariant property of 3D Rajan Transform demonstrated with the help of an example. One can explore the algebraic properties of Multi-Dimensional Rajan Transform as future work.

Acknowledgement

The first author expresses his gratitude to the second and third authors for introducing the fundamental notion of Rajan Transform for carrying out his Post-Doctoral research work.

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Smart Lock using Image Recognition

By Afnanul Hassan, Zaria Fahamida, Proloy Sen & Dr. Syed Akhter Hossain
Daffodil International University

Abstract- In the 21st century, for a digital lifestyle in a smart city, security is one of the core ingredients to ensure digital continuity. The existing smart security technologies use a smartphone, card, and fingerprint that need additional devices to carry or can spread out infectious diseases. Now it is high time to think about an additional device free and more time-consuming technique. So, an intelligent system is proposed in this paper to secure our doors with face authentication. The human face is a unique and easy identifying feature of a human. The registered user's image is saved in the device as a dataset to train the lock. The system recognizes the registered faces very fast and controls the hardware part to be unlocked. The system is capable of detecting and recognizing human faces from a real-time video. It is usable in the door lock, car lock, hutch, and many more security purposes.

Keywords: *face detection, image recognition, open CV, smart lock, raspberry Pi.*

GJCST-G Classification: *I.7.5*

Strictly as per the compliance and regulations of:

Smart Lock using Image Recognition

Afnanul Hassan [α], Zaria Fahamida [σ], Proloy Sen [ρ] & Dr. Syed Akhter Hossain [ω]

Abstract- **In the 21st century, for a digital lifestyle in a smart city, security is one of the core ingredients to ensure digital continuity. The existing smart security technologies use a smartphone, card, and fingerprint that need additional devices to carry or can spread out infectious diseases. Now it is high time to think about an additional device free and more time-consuming technique. So, an intelligent system is proposed in this paper to secure our doors with face authentication. The human face is a unique and easy identifying feature of a human. The registered user's image is saved in the device as a dataset to train the lock. The system recognizes the registered faces very fast and controls the hardware part to be unlocked. The system is capable of detecting and recognizing human faces from a real-time video. It is usable in the door lock, car lock, hutch, and many more security purposes.**

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I. Introduction

Day after day, we are moving towards modernity. But the percentage of home robbed and things stolen is 70.5% [1] of the total crime in the last ten years, and it is escalating, which is a barrier to our smart lifestyle. The existing smart technologies of door security needs memorizing a password or carrying additional devices like mobile phone, cards. Being stolen or lost the additional devices or forgetting the password can hamper the existing smart security systems. Changing the hand of the additional device or getting the password leaked can allow any stranger to pass through the lock. Besides that, the fingerprint system can spread out infectious diseases. Many authors proposed various kinds of digital door locks, password-based locks, etc. [2]. But the solution proposed in this paper is to recognize the valid user's face to unlock the lock because faces are one of the most important visual stimuli [3]. Also, it is a unique feature of every man. From a real-time video, the image of a human face is detected and recognized using the LBPH (Local Binary Pattern Histogram) algorithm. LBPH algorithm has become a standard and mostly used image recognition and detecting technique. Compared with other algorithms LBPH algorithm cannot only recognize the frontal face but also recognize the side face. This algorithm is widely used for image recognition. So, the face authentication technique for security purposes can be a timely and more intelligent idea.

Author α σ ρ: Department of CSE Daffodil International University. e-mails: afnanul15-7213@diu.edu.bd, zaria15-7167@diu.edu.bd, proloy15-7549@diu.edu.bd

Author ω: Professor Department of CSE, Daffodil International University. e-mail: aktarhossain@daffodilvarsity.edu.bd

The paper is organized as follows. Section II summarizes the previous works done by many authors. Section III describes the complete architecture of the proposed system with details of the used algorithm. Section IV contains the conclusion.

II. Related Works

Onoyan A.O. et al. [4] has developed a biometric-based door lock system by using ATMEGA 328 Arduino microcontroller, fingerprint scanner R305. When the fingerprint be matched with the registered fingerprints, a signal is sent to incite the door lock process, and the door stays open for 5 seconds. Adarsh V Patil et al. [5] has manifested an android based smart door locking system. Arduino Uno, android, smartphones have been used to complete this lock security system. A pre-determined password concept is used. Anuradha R.S et al. [6] has proposed an optimized locking and unlocking a process by using a wireless system. The proposed idea had been implemented by using Arduino Uno, DC motor, Wi-Fi. This system aimed to allow a user to lock and unlock a door within the Wi-Fi range from inside or outside a house. Agbo David O et al. [7] has implemented a door locking system using an android app and the Bluetooth module. The app could be connected with the Bluetooth module HC-05 to show the current activity about the door is open or close. If the password is correct, the door will be opened. Otherwise, it will be kept closed. Janaki Venukumar et al. [8] stated that security is the most vital issue nowadays for us when we are out of our households. The proposed project shows a keyless system for operating lock using a pre-defined password. To get entered the must memorize the password. Lia Kamelia et al. [9] proposed that present days are the era of living in smart technology. So, the term "smart home" gives broad thinking to us of living in new technologies. To make the smart home just using the device of our pocket, the mobile phone where Bluetooth will be enough to communicate with devices. Arvasu Chikara et al. [10] proposed a solution for the bank system to secure our money because a bank deserves an extra level of security. The solution is a combination of fingerprint authentication and face authentication. The image and fingerprint data of the authentic persons are saved by the bank authority in the database. The authentic person must match both face and fingerprint to have access to the money of the bank.

The idea of a smart home lock with automated technologies is practiced throughout this decade. But

most of them are developed to work with an android device. Some use Bluetooth and some Wi-Fi. Both of these need an additional device to use the lock. Fingerprint and pre-defined password systems reduced the necessity of extra device but needed user interaction. Moreover, the fingerprint authentication system can spread infectious diseases. Besides all of these systems, our proposed system will work without an additional device and user interaction. The system will just see the user and be unlocked after authentication.

III. System Architecture

The proposed system has an aim to protect premises and belongings smartly and without the necessity of an additional device. It just recognizes the authorized user's faces to unlock the lock. This process can make life easier. In the proposed system, the lock needs to detect and recognize the human face. So, the proposed lock consists of Raspberry Pi 3 which is a low-cost mini-computer in credit card size., which comes with Bluetooth 4.1 and a camera. As shown in Fig. 1 the whole process has two main parts, such as (a) Registration Process and (b) Unlocking process. At the registration process, the 1st user starts from inputting information like name, and then the lock detects and saves 20 images of the user's face to train. On the other hand, any new user must be verified by inputting any previous user's information like name. After training, the lock will be ready to be unlocked, and at the unlocking process, the lock keeps capturing video. If any registered user's face is recognized, it will stay open for 7 seconds and then becomes ready to be locked again.

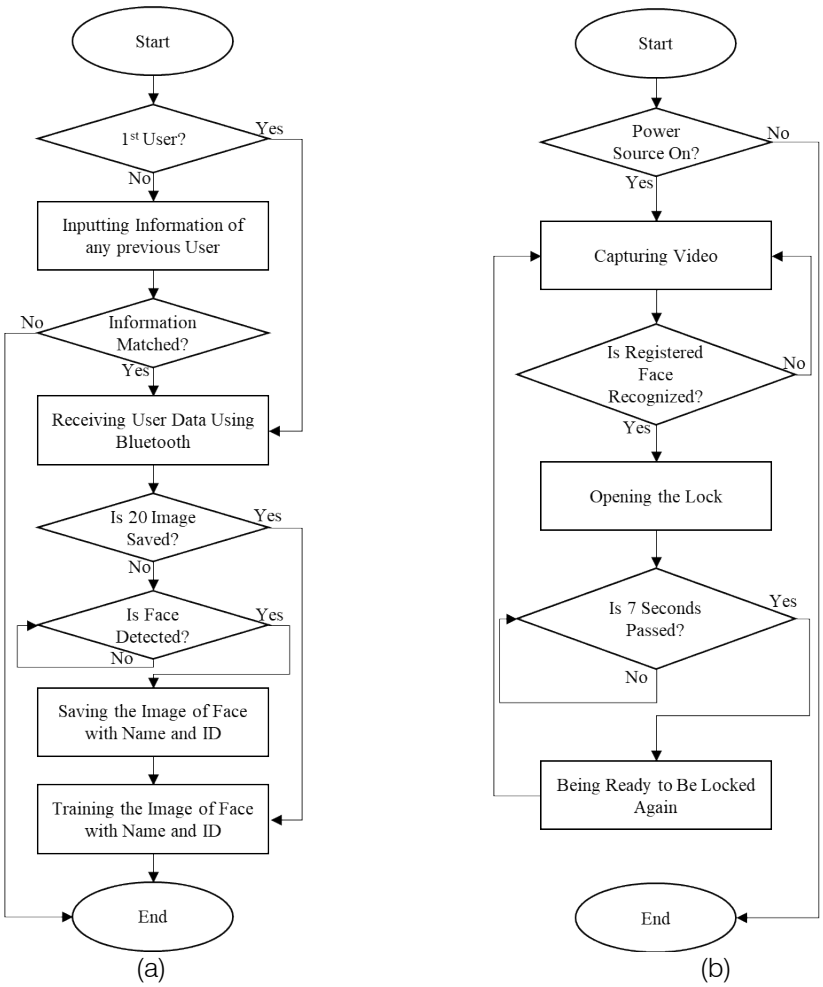

Fig. 1: Flowchart of the Proposed System's Architecture is Showed with (a) Registration Process and (b) Unlocking Process

The complete system architecture can be described in 5 main steps.

a) Receiving User Data via Bluetooth

At the very beginning, the lock needs registered users with face's images to know who is the authentic person. The user can use a mobile application that provides an entirely user-friendly interface to input user data. This is the one and the only use of any additional device. The lock, which is made with Raspberry Pi 3, receives the user information via Bluetooth 4.1 from the

mobile application. The 1st user can be registered without hassle. But in the case of multiple users, other users must input any previous user's information to be registered.

b) Face Detection and Dataset Creation

While the data of new users be received, the lock itself starts capturing real-time video to detect any face. From the video, if any human face is found, the system saves the image's ROI (Region of Interest). Thus 20 faces will be saved along with the name of the new user.

While detecting face, the system converts each frame of video into grayscale to make the task easier. Using the Numpy library, the grayscale image can be converted into an n- dimensional array.

In this case, the OpenCV (Open Source Computer Vision) python library works with the Haarcascade classifier to classify human frontal face, and except ROI (Region of Interest) other numbers of the n-dimensional array will be changed into "0". Thus, the ROI of the face will be classified, and only the face is captured and saved in the lock's dataset. The dataset is created uniquely for an individual lock. So, authentic faces for a deferent lock is different.

c) Training Dataset

The Face detection procedure cannot be completed without training the system according to the dataset. The dataset is combined with the user's name, ID, and image of the user. The name and ID are received from the Android app, and the camera itself will capture the pictures of faces after detection. Combining all of these a file with .yml extension is created to work. When the file is created, the camera becomes ready to recognize the authentic face. The training procedure is done by following the LBPH algorithm.

The LBPH Face Recognizer is a mostly used face detection algorithm [11]. It works with the Numpy array, which is an n- dimensional Array created from the grayscale image of the input image. Now the algorithm is going to be discussed.

The n-dimensional array mainly contains the density of white in every pixel from the range of 0 to 255. As shown in the following Fig. 2 value of every pixel be compared with neighboring pixels in radius 'r'. Here for the pixel threshold, 90 is compared with the neighboring pixel in radius, r = 1. Lower and equal values than the threshold values are changed into '0' otherwise changed into '1'. The binary digits from neighboring pixels can make an 8-bit binary value. Here the 8-bit value is 10001101, which is 141 in decimal. So, the new threshold value is set 141. Thus, the process continues for every pixel.

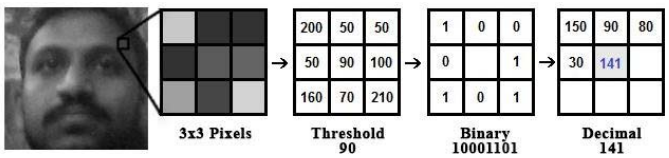

Fig. 2: Applying LBP operation

The LBP Operation can be applied on a large scale just by increasing the value of r. Fig. 3 is visualizing the LBP operation on a large scale if it is used with different values of r.

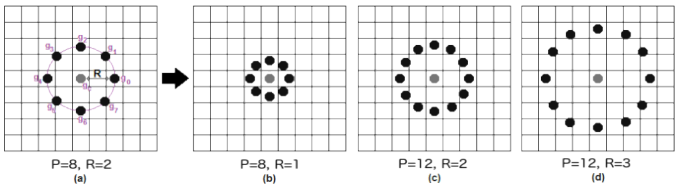

Fig. 3: Visualizing the LBP operation on a large scale

After getting the new threshold value for every pixel, the image changes as Fig. 4. Then dividing the image into 8x8 blocks. Every block's all threshold values can be expressed with histogram. Though there is a grayscale image, each histogram (from each block) represents only the intensity of white in each block within 256 (0-255) positions. Finally, combining each histogram, a large histogram is created. Here, 8 * 8 * 256 = 16,384 can be found.

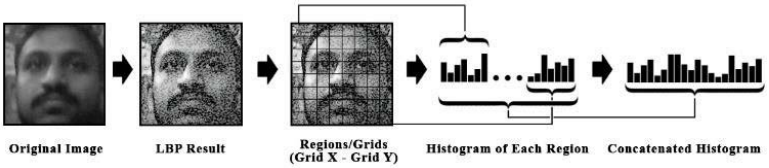

Fig. 4: Extracting histogram

The final histogram signifies the key image topographies of the image. The LBPH algorithm works the same for each face, and everything keeps saved in a .yml file

d) Recognizing Face to Unlock the Lock

This step is the most significant because the algorithm is now trained. Each histogram formed mainly signifies each image in the registered users' dataset. Henceforward, the system takes input images from the camera. For the input image of a new person, the same steps are taken to create a histogram that signifies the input image. Now the final histogram (hist2) is compared with the trained images' histogram (hist1). A difference, D is calculated for all images of n number in the dataset according to the following Eq. (1) [12].

$$D = \sum_{i=1}^{n} \min(hist1_i - hist2_i)^2 \qquad (1)$$

The minimum value of D defines the matching with the input image and the specific image. If any matching happens, the person recognizes as an authentic person. If the person is authentic, the lock unlocks. Otherwise, it remains the same without being opened.

e) Unlocking the Lock

Whenever the lock recognizes any face from the database, the lock outputs a "1" that provides current to a servo motor. The servo motor rotates a disk, and the disc helps to unlock the lock. The mechanism of working is shown in Fig. 5. Where the servo motor can turn the wheel, and the wheel works to lock and unlock the device.

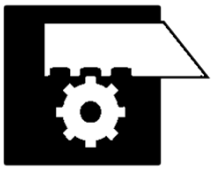

Fig. 5: Unlocking mechanism of the lock

IV. Expected result and Discussion

The proposed idea can register new faces and then identify those to open the lock. the dataset is created with registered users' frontal faces to train the machine. The system takes 20 faces of each user. The faces are saved with the user name and unique ID. Fig. 6 shows the dataset creates for an individual user.

Fig. 6: Dataset created for an individual user with a unique ID

Every image turns into an n-dimensional Array. Using radius: 1, neighbors: 8, grid_x: 8, grid_y: 8 of LBPH algorithm, the n-dimensional array of the trained images looks like Fig. 7.

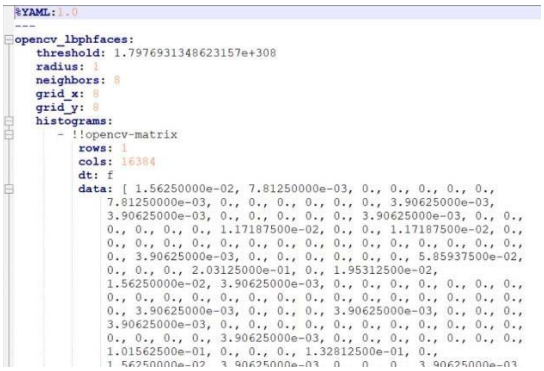

Fig. 7: The n-dimensional array of every image after training

After training the proposed system waits for the registered faces and if found it opens within a moment otherwise remains closed. The effectiveness or accuracy of the system is calculated using Eq. (2) [13].

$$Accuracy = \frac{Number\ of\ Currect\ Predictions}{Total\ Number\ of\ Predictions} \qquad (2)$$

The accuracy is measured by counting the number of correct predictions and the total number of predictions. For this proposed idea the accuracy is calculated 76%. A quality camera and enough light give a more accurate performance. The process is so fast that it takes about no time to be unlocked if any registered face is found.

V. Conclusion

The proposed idea of using image recognition in a lock can make lives smarter. The system uses the

OpenCV computer vision library to recognize the authentic registered user by image processing. Working with every pixel of an image makes the system more accurate. According to the registered users' dataset it can recognize faces accurately. In low light, it may take a few more seconds to recognize. But enough light gives a perfect service.

The experimental result shows that the system can detect and recognize one or more than one face from a real-time video. At least one authentic face is enough to open the lock. The system can be widely used in any security purposes like a door, car, hutch, etc.

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Specifying a Model for the Study of Social Entrepreneurship

By Cruz García Lirios

Abstract- The purpose of the work was to specify a model for the study of social understanding. A documentary, cross-sectional and exploratory study was carried out with a non-probabilistic selection of sources indexed to international repositories, considering the indexation, year of publication and impact factor. Discussion axes were established to address the problem, although the research design limited the findings to the sample analyzed, suggesting the extension of other repositories, years and quality indicators.

Keywords: heads of family, social work, entrepreneurship, specification, model.

GJCST-G Classification: J.4

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I. Introduction

Social Work studies about entrepreneurship warn a process of deliberate, planned and systematic rational choice which promote quality of life and subjective well - being are predominant determinants.

The aim of this study is to specify a model for the study of social entrepreneurship in household heads. From a review of the literature, the variables that allowed the systematization of the determinants of entrepreneurship paths are extracted.

Specify a model for the study of entrepreneurship in household heads.

II. Theory of Social Entrepreneurship

The principles that guide the rational choice lie in the tastes and preferences crystallizing objectives of the actors. Therefore, before taking any decision binding preferences strategies, achieve collect information that will determine the election. If individuals rather have an indeterminate number of tastes, objectives and goals, then your preferenceswill no longer depend on their capacity of choice and action. Therefore, they act in a non-rational way.

The rational choice theory also warns that a decision is a result of an estimate of the costs and benefits of carrying out an effort regardless of their degree of significance. This is a utilitarian dimension in which control of a situation from establishing a favorable balance of benefits versus costs will determine the election.

More specifically, the benefits and costs translate into a ratio of risk, effort and reward. This means that a choice be rational when the risks and efforts are minimal provided that the rewards are greater (Amrouni and Abdelwahed, 2014).

In contrast, when the recognition of an effort and risk not up to expectations, then the choice has not been entirely rational and rather approaches an irrational dimension if the risks and efforts are increasing and intense with respect to the absence of rewards.

This is because the individual who makes an effort is committed to the risks that will be activated by profit expectations.

Integrating each of the variables represents a series of paths in which the correlations explain each choice

In short, the rational choice explained in general terms the process by which preferences are the determining factor by other factors which generate information or sense an atmosphere of certainty when making a decision and act accordingly. To the extent such information is available, accessible and actionable, then the rational choice will emerge as an option, but rather proliferates ambiguity, then a non - rational decision will be generated with irrational consequences.

However, when information is not available or is very abstract, rational choice is replaced by a tighter option to culture; values and norms of people with respect to a contingency which no known precedent some, but people always react the same way.

III. Studies of Social Entrepreneurship

If rational choice is brewing from preferences based on information available to determine tastes and objectives, the prospective attitude suggests that the absence of information creates uncertainty that determine risk aversion or waiver of certain gains and risk appetite when losses are imminent. Thus the utility, benefit or happiness crystallize into losses or gains, circumventing the process of rational choice and legitimizing an irrational choice.

Therefore, a prospective is more than a decision lies in attitude and expectation of risk or certainty to gains and losses in the immediate future. In that sense, a retrospective is an attitude that is the same relations, but compared to last (Carr and Sequeira, 2007).

In short, the prospective attitude is a hinge between rational choice and reasoned action. Each of these theoretical and conceptual frameworks based its scope and limits from the availability of information,

Author: e-mail: bundestrans@gmx.es

assuming that the individual is able to assume an attitude, make a decision or take an action that corresponds to the available information and representation that you have it.

IV. Models of Social Entrepreneurship

Unlike the rational choice theory that focuses on the usefulness of the information available and the theory of prospective attitude that focuses its interest in the certainty of the information, the theory of reasoned action assumes that information, any it is, it is a general environment that will influence the behavior to the extent that information is transformed into rules. This is because the theory of reasoned action considers that all information is cognitively processable (Ferreiro, 2013).

Therefore, an overview of the environment, their demands and opportunities conducive categories of accessible and abundant availability of information that will influence a spendthrift behavior such as believing that jobs, wages and financial credits significantly increase. On the contrary, if one considers that the context is rather recession and economic crisis, then austere styles, cooperative and innovative life will be adopted.

However, the theory of reasoned action, like the rational choice theory and the theory of prospective attitude, pose a general scenario incident on a specific behavior without considering the current situation and specifies decision maker.

V. Method

The study is part of the Division of Humanities and Social Sciences, Social Work discipline, area of health promotion and sub-area of promotion of reproductive rights, parental rearing styles and management of household heads.

However, the project also has interference in economic and administrative sciences, as it will recover in the second phase the effect of cooperative entrepreneurship in Human Development with an emphasis on reproductive health, family upbringing and training of entrepreneurs.

Not experimental, documentary and retrospective study with a nonrandom selection of sources indexed repositories Latin America -Dialnet, Latindex, Redalyc-, considering the keywords and the publication period 2010-2019.

The Delphi technique was used to evaluate the findings consulted in the literature reviewed. Three rounds of analysis were established; 1) evacuation, 2) feedback and 3) synthesis in order to establish the central themes, themes and categories of the research agenda.

The data were processed in the qualitative analysis package for social sciences version 3.0 considering the categories and their contingent relationships for the establishment of trajectories.

VI. Results

A model with eight hypotheses three paths dependency relationships between nine variables put forward in the state of knowledge was specified.

Given that the information is not available or is processable actors requiring immediate planning of their actions, the determinants of the planned behavior are those in which information can be delimited and specified depending on a particular situation or to an event which is the subjective control from decision-making and the information available and actionable (Fuentes and Sanchez, 2010).

The theory of planned behavior finds that perceived control is a significant determinant of behavior in direct and indirect mode. To interact with subjective norms and attitudes generate an intention that is also assumed as a determinant of behavior.

However, it perceived control, as the norm and attitude, depend on a set of beliefs about information availability. In this sense, the specification of a model would include variables that anticipate the behavior, but not from the beliefs of availability of information, but from provisions to cooperate by actors that form an entrepreneurial project to develop their skills, not only of choice, deliberation or planning, but innovation.

VII. Discussion

The inclusion of variables relating to the quality of life and subjective well - being as a result of the determination of the enterprise warns. Such a model would anticipate local development scenarios.

From brandished variables; beliefs, rule, attitude, perception, intention and behavior, you can specify a model for the study of social entrepreneurship in household heads engaged in the production and marketing of coffee. The model includes eight hypotheses:

This is the case of social work that develops in health institutions and educational. Often, the practitioner of Social Work promotes sexual rights in an open group of people without considering other factors that information concerning sexual health, with emphasis on sex or coital (Garcia, 2015).

In scenarios such as broadcast stations public transport system or concourses, the promoter exposes the benefits of using condoms to negotiate safe sex. The goal of this promotion is to influence consensual sex from use almost always male or female condom.

Control is a more focused advocacy groups exposed to sexually transmitted diseases (STDs); sex workers or people on the street. The aim of such

promotion is to provide a tool to avoid getting an STD again, focusing on the lifestyles of potential victims.

In schools and health centers, promoting sexual rights seeks to counter the effect of the norms and values that proliferate in the beneficiaries or students about the myths and realities of sexuality. It is considered that prevention should be focused on changing sexuality limited exploratory concerted and sexuality (Garcia, Carreon Hernandez Aguilar and Rosas, 2015).

This is an innovative path, as the literature reviewed, has not contemplated the possibility of integrating the promotion of sexual rights as a determinant indirect attitude towards entrepreneurship. This is because the impact on the beliefs of sexual control means planning that could spread and impact on an entrepreneurial project of social character as is the case of a cooperative. That is, if the household heads know the basics of planning, then you can implement this tool in creating a socially responsible company.

On this track, the successful cases of promoting reproductive health on birth control and reducing the population explosion are strong evidence that the information specifically on a particular situation as a better quality of life in small families adopting generated and contraceptive methods and family planning techniques.

Once in health centers or public schools has spread information about sexual rights, negotiating with himself and with others about exploring tastes, needs and sexual preferences, then seeks to observe this process in decision-making at the choice of partner, negotiating condom use or agreement to request termination of pregnancy through the morning - after pill or medical care (Rodríguez, 2009).

If it is possible to establish a link between the processing of information regarding the planning of sexuality and it is possible to observe their effects on favorable attitudes to entrepreneurship, then It is useful to identify the cases of those who were intended to share entrepreneurial projects with some companions of the course or workshop planned promotion of sexuality.

The effects of distributing emergency contraception or requesting abortion assisted on the control of sexual encounters and STD prevention can be seen in the intentions of carrying out actions that promote lifestyles planned regarding improvised decisions.

In this path, the promotion of indirect sex as adetermining rights of social entrepreneurship is particularly important, since diffusion of unprotected sex, the use of morning - after pill or any application for termination of pregnancy would be indicators of a personal and group change in different circumstances and in different situations with regard to management and time management which is an estimate of hours devoted to the development of a project (Loui Carpio and Vergara, 2012).

This is a widely recommended by the literature reviewed path, as it explains in detail the stages that information about opportunities and capabilities entrepreneurship affect family planning decisions or where appropriate the adoption of methods and techniques that favor the development of women with the opportunity to not only prevent pregnancy, but also develop strategies for socially responsible entrepreneurship. That is the profile of these women would be to prioritize the avoidance of pregnancy is an opportunity to organize themselves to ensure a favorable themselves and the group they belong income as well as provide a financial guarantee for their future descendants if the case, or, supporting single mothers who do not have the possibility of undertaking a project (Obrego, 2008).

Although the literature identifies 8b hypothesis as the most viable, in this case 8c is possible to notice that the path includes variable perceived control as a determinant of decision-making and entrepreneurial action. This variable involves a high degree of family or temporary planning from which it is possible to anticipate scenarios of unwanted pregnancies, cultural and family pressure, marital conflict or any other factor that inhibits the decision to prioritize entrepreneurship and innovation at the option of pregnancy and parenting.

VIII. Conclusion

The specification of a model for the study of entrepreneurship in household heads is the contribution of the state of knowledge work. From a review of the literature the eight hypotheses explaining three paths of correlations between the variables put forward in the literature reviewed were specified.

However, studies of social work around the venture have not included variables that explain the decision-making and entrepreneurship from affectivity, emotionalism or sentimentality associated with female gender identity.

In this sense, the literature seems to corroborate the hypothesis around which the male identity is enterprising and as such are attributed innate abilities of opportunism, management and negotiation lacks female identity.

However, studies of the promotion of entrepreneurship locate these assumptions in an ambivalent sexism, because on the one hand emphasize the feminine attributes of good treatment and friendliness, but extol the perception of opportunity and negotiating skills as own identity male.

It is therefore necessary to review theoretical, conceptual and empirical frameworks with a gender

perspective to demonstrate the scope and limits of female and male identities identities to an entrepreneurial opportunity.

The specification of an integrated model in which the gender perspective is included, explain the scope and limits of feminine identities and masculine identities to the entrepreneurial opportunities because the model should overcome the traditional sexism and ambivalent sexism to explain entrepreneurship in single mothers and female heads of households engaged in trade, buying and selling products at retail.

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for writing a good quality Computer Science Research Paper

Techniques for writing a good quality computer science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10.Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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