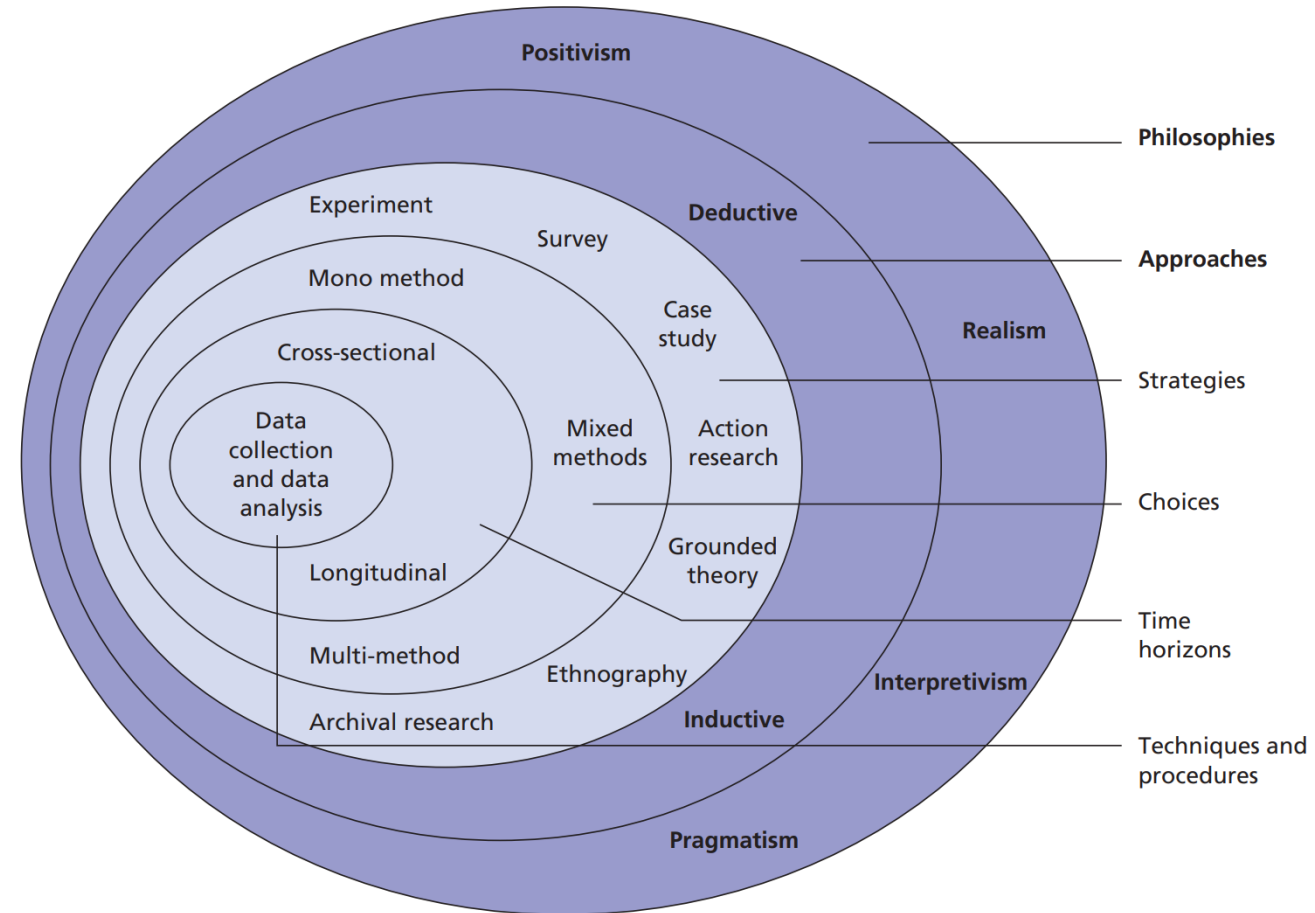


Research Methodology

Research Design

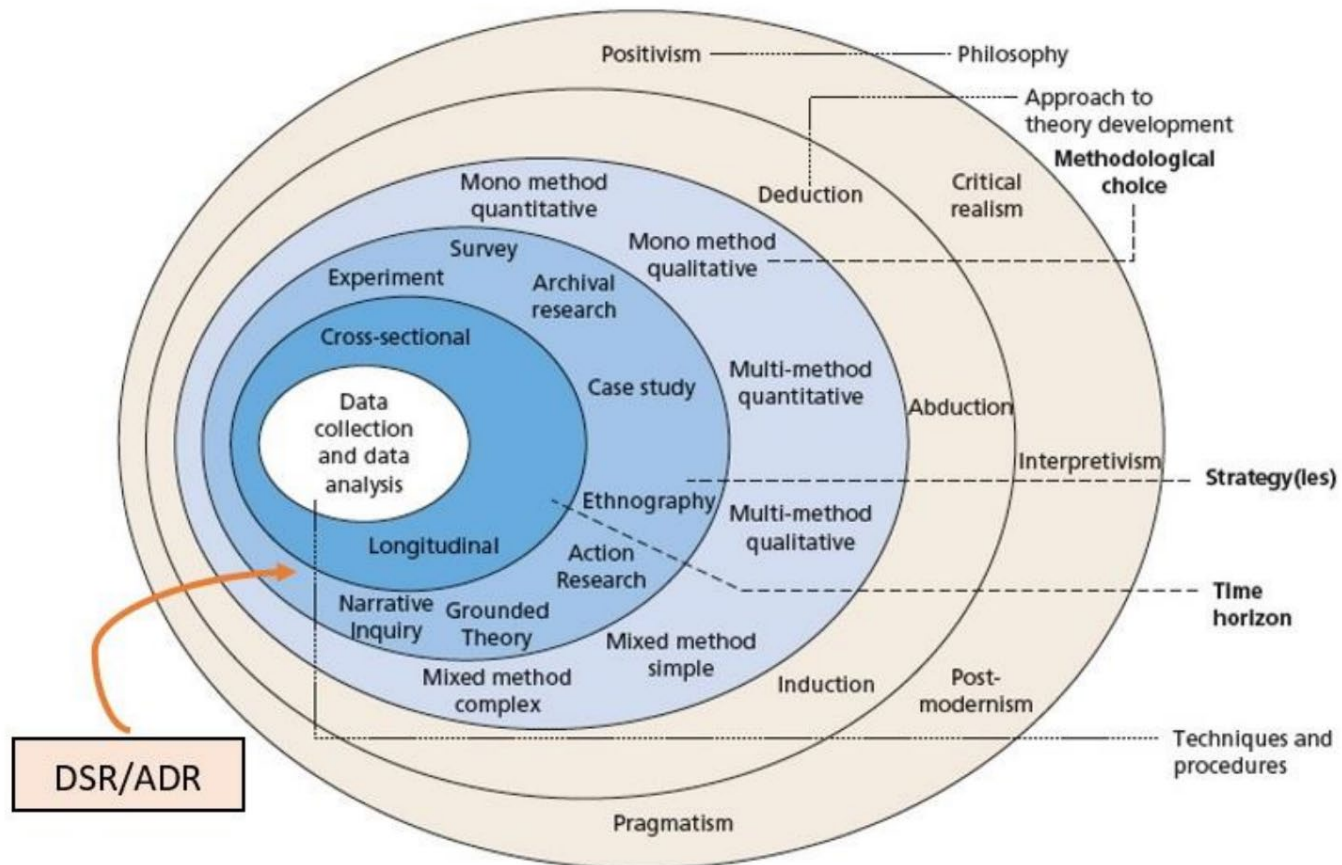
- Research Onion



Saunders, et.al, 2009.

Research Design

- Modified Research Onion



Source: Mardian, 2020.

Design Science Research

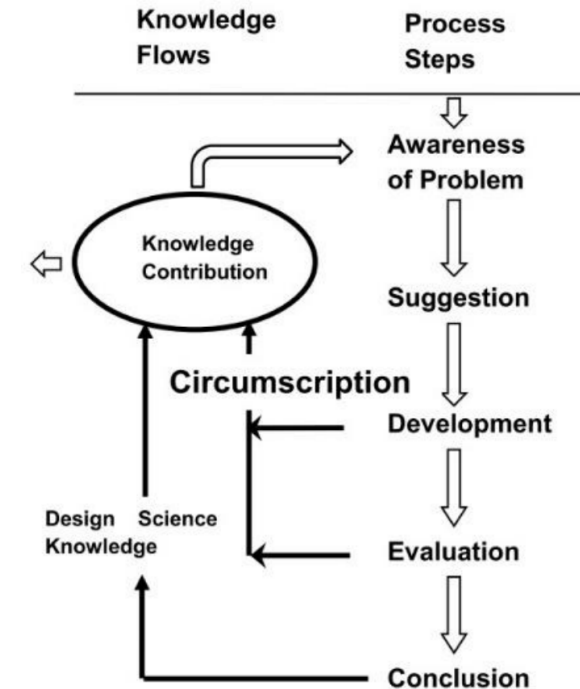
- Design science research is an important research framework of several technical discipline such as computer sciences and engineering.
- Design science research is characterized by the design and development of more effective and efficient solutions to the previously solved problems (Kuechler and Vaishnavi 2008).
- Thus design science research is considered as a fusion of practice, research and design and is comparable to the exploration of knowledge through focused design (Faste and Faste 2012).
- The approach of design science research commences with the conceptualization of a problem and concludes with the evaluation of the effects of the artifacts developed to ameliorate the identified problem (Ellis and Levy 2010).

Design Science Research

- This, design science research is focused on the successful creation and evaluation of artifacts (Hevner and Chatterjee 2010).
- These artifacts may comprise of constructs, algorithms, models, tools, methods, technical or social informational resources and instantiations (Hevner *et al.* 2004; Hevner and Chatterjee 2010).
- Hence the artifacts can be broadly defined as any designed object with an embedded solution to an identified research problem (Peppers *et al.* 2007)

Design Science Research Process

- The final objective of design science research is to provide an effective and efficient artifacts embedded with the solution to the research problem.
- Design Science Research Cycle
 - identification of problem
 - objective definition
 - artifact design and development
 - Evaluation
 - Communicating the results



Source: Mardian, 2020

Design Science Research Process

- The research process is structured in a sequential order of these design components.
- Six-phase framework for the design and development of design science research artifacts (Figure 1).

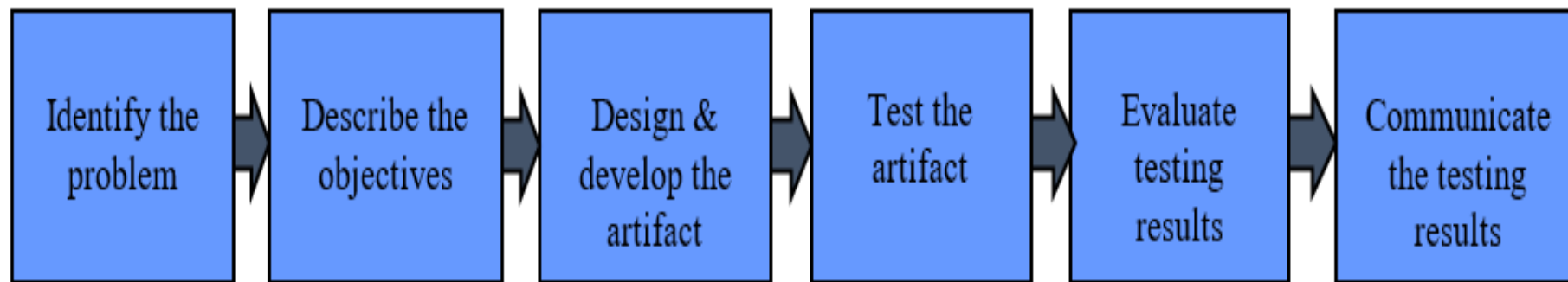


Figure 1 : Design and development framework (Ellis and Levy 2010)

Design Science Research Process

Identify the problem

- Identification of the problem is the crucial starting stage in the design science research as this phase assists to provide a solution by developing an effective artifact (Hevner et al. 2004; Peffers et al. 2007; Ellis and Levy 2010).
- A problem is the difference between the current state and the goal state and this difference can be mitigated or eliminated with an effective artifact (Simon 1996)

Design Science Research Process

- Example of a problem (Problem 1)

- *Due to the heterogeneous properties of images, an effective and efficient segmentation method for a diverse class of image is still an open problem. Myriads of classical image segmentation algorithms have been developed over the years yet generalization and universal optimum performance are far away from ideal levels (Xu and Wunsch 2005; Pereira et al. 2020; Nikbakhsh, Baleghi and Agahi 2021). Further, the clustering based image segmentation algorithms are largely hooked on the initial cluster count because an incorrect selection of initial cluster counts results in an incongruous segmentation output. Identification of an optimum cluster count is a common issue in clustering based image segmentation. Hence this study aims to develop a general clustering based segmentation algorithm that can address the aforementioned problem of clustering based segmentation algorithms to some extent.*

Design Science Research Process

Define the objectives

This phase is closely link to the previous phase as the objectives are clearly related to the problem and must be inferred directly from the specified problem (Peffers et al. 2007).

Knowledge about the current state of the problem and the existing solution is of paramount important to derive the objectives.

Design Science Research Process

- Example of objective based on the problem 1
- *To perform a comprehensive review on existing clustering based image segmentation algorithms*
- *To identify a set of salient image features that work well on a diverse class of images*
- *To construct a novel clustering based image segmentation algorithm that automatically identifies the optimum cluster count and exploits the identified salient features to achieve an effective and efficient image segmentation process*

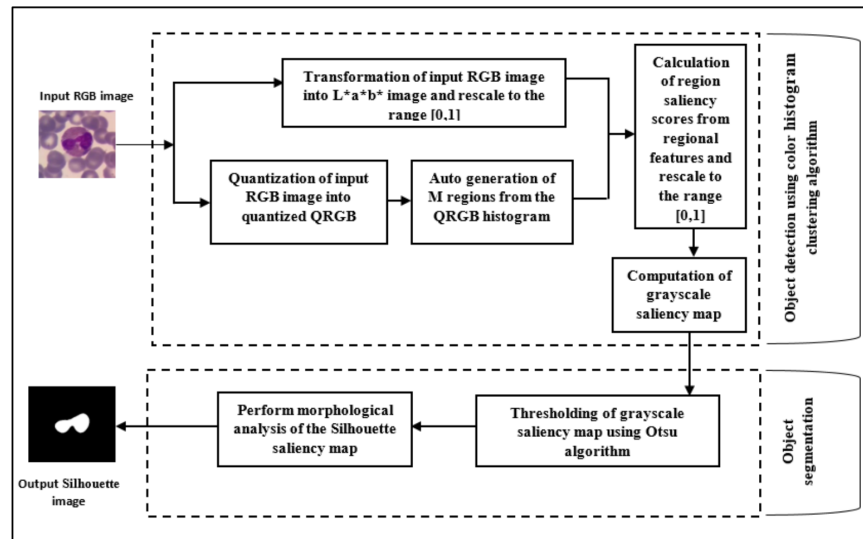
Design Science Research Process

Design and develop the artifact

- This phase includes the creation of an artifact and it comprises of the determination of the preferred functionality of the artifact, designing the architecture and the actual development of artifacts (Peffers *et al.* 2007).
- The theoretical knowledge to bear the effective solution for the identified problem is the essential resource for the movement from objectives to design and development.

Design Science Research Process

Design and develop the artifact Example



Flowchart of the proposed algorithm

Algorithm 1 Color Histogram Clustering

Input: $M \times N \times 3$ RGB color image (Input), distance scaling parameter (n) such that $0.1 \leq n \leq 1.0$
Output: $M \times N$ Silhouette image (Output), number of clusters automatically detected (K)

% Constant parameters

NIC=3; % number of image components

IQL=8; % image quantization level

NCD=IQL^3; % maximum number of desired colors

LCL=1; % lab color light

LCA=2; % lab color A

LCB=3; % lab color B

PXC=4; % pixel x-coordinate

PYC=5; % pixel y-coordinate

PDC=6; % pixel distance to image center

CPC=7; % cluster pixel count

CPL=8; % cluster pixel label

CCC=8; % cluster color contrast

CSS=9; % cluster saliency score

```
1. K=0;
2. Index=ImageQuantization(Input, IQL);
3. Input=rgb2lab(Input);
4. Input=rescaleImage(Input, [0,1]);
5. for x = 1 to M do
6.   for y = 1 to N do
7.     Palette(index(x, y), CPC)=Palette(index(x, y),CPC)+1;
8.     Palette(index(x, y), LCL)=Palette(index(x, y), LCL)+Input(x, y), LCL);
9.     Palette(index(x, y), LCA)=Palette(index(x, y), LCA)+Input(x, y), LCA);
10.    Palette(index(x, y), LCB)=Palette(index(x, y), LCB)+Input(x, y), LCB);
```

Part of the proposed algorithm

Design Science Research Process

Test the artifact

This phase involves the experimentation, simulation or any similar activity used to demonstrate the ability of the artifacts to meet the functionalities and requirements established during the design and development phase (Peppers *et al.* 2007; Ellis and Levy 2010).

It is important to ensure the applicability of the developed artifacts in the proposed context and demonstration of the reasonable solution in addressing the problem.

Design Science Research Process

Test the artifact

Testing the proposed algorithm in terms of evaluation metrics such as Accuracy, Precision, Recall, F Measure, MAE etc.

Test results Example

Boundary Image	Center Images	Complex background	Overlap images																																																
<table><tr><th>Metric</th><th>CHC</th></tr><tr><td>Precision↑</td><td>0.945</td></tr><tr><td>Recall↑</td><td>0.891</td></tr><tr><td>F-measure↑</td><td>0.932</td></tr><tr><td>MAE↓</td><td>0.062</td></tr><tr><td>OR↑</td><td>0.844</td></tr></table>	Metric	CHC	Precision↑	0.945	Recall↑	0.891	F-measure↑	0.932	MAE↓	0.062	OR↑	0.844	<table><tr><th>Metric</th><th>CHC</th></tr><tr><td>Precision↑</td><td>0.949</td></tr><tr><td>Recall↑</td><td>0.889</td></tr><tr><td>F-measure↑</td><td>0.934</td></tr><tr><td>MAE↓</td><td>0.067</td></tr><tr><td>OR↑</td><td>0.846</td></tr></table>	Metric	CHC	Precision↑	0.949	Recall↑	0.889	F-measure↑	0.934	MAE↓	0.067	OR↑	0.846	<table><tr><th>Metric</th><th>CHC</th></tr><tr><td>Precision↑</td><td>0.933</td></tr><tr><td>Recall↑</td><td>0.753</td></tr><tr><td>F-measure↑</td><td>0.885</td></tr><tr><td>MAE ↓</td><td>0.120</td></tr><tr><td>OR↑</td><td>0.710</td></tr></table>	Metric	CHC	Precision↑	0.933	Recall↑	0.753	F-measure↑	0.885	MAE ↓	0.120	OR↑	0.710	<table><tr><th>Metric</th><th>CHC</th></tr><tr><td>Precision↑</td><td>0.986</td></tr><tr><td>Recall↑</td><td>0.767</td></tr><tr><td>F-measure↑</td><td>0.925</td></tr><tr><td>MAE↓</td><td>0.134</td></tr><tr><td>OR↑</td><td>0.757</td></tr></table>	Metric	CHC	Precision↑	0.986	Recall↑	0.767	F-measure↑	0.925	MAE↓	0.134	OR↑	0.757
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Design Science Research Process

Evaluate testing results

- Observation and the measurement of the performance of the artifacts in supporting the solution to the problem is addressed in this phase.
- During this evaluation phase, the validity of the developed artifact is assessed based on the nature of the problem.
- This phase includes the qualitative and quantitative comparison of the obtained results to the predicted solution.
- Knowledge of significant evaluation metrics and analysis techniques are the required resource to accomplish the evaluation phase.

Design Science Research Process

- Evaluate testing results

Qualitative and Quantitative comparison

Datasets	HKU-IS					SOC				
Metrics	Precision	Recall	F-Measure	MAE	OR	Precision	Recall	F-Measure	MAE	OR
DCLC	0.724	0.653	0.707	0.160	0.517	0.558	0.499	0.543	0.215	0.236
DGL	0.725	0.672	0.712	0.189	0.528	0.568	0.505	0.552	0.263	0.244
DRFI	0.753	0.755	0.754	0.144	0.577	0.560	0.563	0.561	0.219	0.356
MSNSD-A	-	-	0.837	0.071	-	-	-	-	-	-
MSNSD	-	-	0.837	0.071	-	-	-	-	-	-
MCDL	-	-	0.743	0.093	-	-	-	-	-	-
CHC	0.813	0.673	0.776	0.144	0.578	0.650	0.531	0.618	0.202	0.389

PH2 dataset (200 images)

Method	Accuracy	Sensitivity	Specificity	Dice
SSLS (Ahn <i>et al.</i> 2015) ^a	0.85	0.75	0.98	0.78
ASLM (Pennisi <i>et al.</i> 2016) ^a	0.90	0.80	0.97	0.83
(Youssef <i>et al.</i> 2018) ^b	0.89	0.92	0.87	0.87
(Rajput, Tanwar and Raman 2021) ^a	0.86	0.83	0.92	0.88
(Patiño, Avendaño and Branch 2018) ^a	0.90	0.91	0.89	0.89
SDI+ (Guarracino and Maddalena 2019) ^a	0.91	0.92	0.90	0.85
(Salih and Viriri 2020) ^a	0.92	0.84	0.96	0.90
SPCA (Bi <i>et al.</i> 2016) ^b	0.87	0.73	0.95	0.80
YOLO (Ünver and Ayan 2019) ^b	0.93	0.84	0.94	0.88
CHC ^a	0.92	0.85	0.98	0.89

^a unsupervised method; ^b supervised method.

Design Science Research Process

- Evaluate testing results

ECCSD data set (1000 images)



Method	Precision	Recall	F-measure	MAE	OR	Method	Precision	Recall	F-measure	MAE	OR
CHC	0.853	0.635	0.790	0.163	0.573	GR	0.714	0.391	0.600	0.283	0.348
AC	0.439	0.300	0.396	0.210	0.263	HDCT	0.767	0.640	0.733	0.198	0.519
BGFG	0.723	0.606	0.692	0.208	0.467	IT	0.570	0.406	0.521	0.289	0.285
BPFS	0.660	0.820	0.690	0.166		MAP	0.758	0.661	0.733	0.185	0.534
CA	0.532	0.374	0.485	0.310	0.266	MC	0.768	0.652	0.738	0.202	0.531
CNS	0.708	0.600	0.680	0.166	0.480	MCVS	0.780	0.540	0.700	0.170	
COV	0.679	0.527	0.636	0.215	0.388	MR	0.767	0.647	0.736	0.186	0.525
CSV	0.760	0.650	0.740	0.210		MRBF	0.780	0.670	0.760	0.177	
DCLC	0.769	0.636	0.734	0.182	0.530	RPC	0.629	0.489	0.590	0.218	0.372
DGL	0.785	0.655	0.750	0.191	0.548	SEG	0.662	0.230	0.462	0.340	0.212
DRFI	0.794	0.698	0.769	0.170	0.572	SeR	0.366	0.207	0.311	0.404	0.144
DSR	0.753	0.647	0.726	0.171	0.517	SIM	0.365	0.078	0.197	0.433	0.062
FBSS	0.770	0.560	0.709	0.169		SR	0.460	0.302	0.411	0.311	0.212
FCB	0.721	0.515	0.660	0.173	0.422	SUN	0.384	0.102	0.235	0.437	0.087
FES	0.672	0.545	0.638	0.212	0.404	SWD	0.704	0.354	0.573	0.318	0.283
GB	0.629	0.519	0.600	0.263	0.364						

Design Science Research Process

Evaluate testing results



	1	2	3	4	5	6	7	8	9	10
Image										
GT										
CHC										
SPCA										
SD+										



(a) ECSSD										
	1	2	3	4	5	6	7	8	9	10
Image										
GT										
CHC										
AC										
BFG										
CA										
CNS										



SOC	Dataset	Image	GT	CHC	CNS	DCLC	DGL	DRFI	DSR	GR
	1									
	2									
	3									
	4									

Design Science Research Process

Communicate the testing results

- This phase entails the contribution to the body of knowledge by providing a complete communication of results and the conclusion of the study.
- The research problem, artifacts, the utility and novelty of artifacts, effectiveness of the artifacts are reported and communicated in this phase using scholarly research publications.
- The research problem, the designed artifacts and the results are published in a scholarly journal.

Design Science Research Process

- **Communicate the testing results**

Example

- Publications



Journal of
Imaging



Article

Detecting Salient Image Objects Using Color Histogram Clustering for Region Granularity

Seena Joseph and Oludayo O. Olugbara *

Experimental comparison of ten state-of-the-art saliency detection algorithms for segmenting leukocyte nucleus

Publisher: **IEEE**

[Cite This](#)

PDF

[Seena Joseph](#) ; [Oludayo O. Olugbara](#) [All Authors](#)



diagnostics



Article

Preprocessing Effects on Performance of Skin Lesion Saliency Segmentation

Seena Joseph and Oludayo O. Olugbara *

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