एन्हान्सिंग कैपेबिलिटीज़ एंड एफिशिएंसी ऑफ एज-डिवाइसेस इन लॉन्ग-रेंज आइओटी यूज़िंग मशीन लर्निंग

Enhancing Capabilities and Efficiency of Edge-devices in Long-Range IoT using Machine Learning

Thesis submitted in partial fulfillment
for the Award of Degree

Doctor of Philosophy

by

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Dedicated to my parents,
and
my elder brother

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Ramakant

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List of Symbols

Symbol	Description
$\mathcal{P}$	Set of participants
$\mathcal{D}$	Server dataset
N	Number of participants
$\mathcal{D}_i$	Dataset at p_i
$\mathcal{S}$	Similarity-score
$\{$	Feature vector
ϵ_o^c	Threshold
$\mathcal{C}$	Centroid
n	Length of vector
E	Number of local epochs
$\mathcal{W}$	Weight parameter matrix
ϕ_i^c	Fraction of dataset
m_i	Number of instances in $\mathcal{D}_i$
$\mathcal{D}_i^c$	Dataset at p_i for class c
m	Number of instances in $\mathcal{D}$
s	Spreading factor
d_r	Data rate
c^r	Coding rate
$\mathcal{D}$	Dataset
d	Dropout
α	Residual energy
β	Available memory
γ	Task fraction
$\mathcal{N}$	Number of UAVs
$\mathcal{L}$	Loss function
n	Total instances in $\mathcal{D}$

Symbol	**Description**
k	Number of classes
$\mathcal{M}^t$	Teacher (large-size DNN)
$\mathcal{T}$	Flight time
$\mathcal{M}^s$	Student (lightweight DNN)
$\mathcal{A}$	Attribute matrix
$\mathbf{x}_i$	i^{th} instance of $\mathcal{D}$
$\mathcal{Z}$	Semantic matrix
$\mathcal{L}_{term}$	Loss term
$\mathcal{R}_{term}$	Regularization term
$\diamond$	Built classifier
δ	Distance threshold
$\mathcal{T}$	Low rank representation of $\mathbf{Y}$
$\mathcal{L}_a$	Loss term to conquer true label prediction
$\mathcal{L}_b$	Loss term to conquer false label prediction
$\mathcal{L}_{NAL}$	Noise adaptive loss
ϕ_i	Probability of true label for i^{th} instance in $\mathcal{D}$
E	Epochs for model training
e	e^{th} epoch, $1 \leq e \leq E$
$\lfloor$	Bias vector
B	Bandwidth
η	Learning rate
$U(\cdot)$	Utility function
$\mathcal{P}$	Set of participants
ϱ_i	i^{th} participant, $\varrho_i \in \mathcal{P}$
$\mathcal{L}_{DL}$	Distillation loss
$\mathcal{L}_{AL}$	Attention loss
$\mathcal{L}_{CE}$	Cross-entropy loss
R	Number of global iterations
$W^{[t]}$	Weight parameter matrix at iteration t, $1 \leq t \leq R$
M_o	Generic model
M_i	Model at participant ϱ_i, $\varrho_i \in \mathcal{P}$

Abbreviations

Abbreviation	Description
ADR	Adaptive Data Rate
DR	Data Rate
AS	Application Server
CE	Cross Entropy
CNN	Convolutional Neural Network
CR	Compression Ratio
DL	Distillation Loss
DNN	Deep Neural Networks
ED	Edge Device
FL	Federated Learning
IMU	Inertial Measurement Unit
ITS	Intelligent Transportation System
KD	Knowledge Distillation
LN	LoRa Node
LG	LoRa Gateway
NAL	Noise Adaptive Loss
NS	Network Server
PS	Payload Size
RSSI	Receiver Signal Strength Identification
SF	Spreading Factor
SNR	Signal to Noise Ratio
TP	Transmission Power
UAV	Unmanned Aerial Vehicle
WPM	Weight Parameter Matrices
CSS	Chirp Spread Spectrum