% Styles

% Mathematics signs

\newcommand{\inv}[1]{\frac{1}{#1}}

\newcommand{\given}{\: | \:}

\def\defined{{\stackrel{\scriptscriptstyle \Delta}{=}}}

\newcommand{\Img}{\mbox{Im}\,}

\newcommand{\Ker}{\mbox{Ker}\,}

\newcommand{\mbf}[1]{{\mbox{\boldmath $#1$}}}

\newcommand{\ceil}[1]{\left\lceil #1 \right\rceil}

\newcommand{\floor}[1]{\left\lfloor #1 \right\rfloor}

%Misc

\newcommand{\bra}{\begin{eqnarray}}

\newcommand{\era}{\end{eqnarray}}

\newcommand{\ignore}[1]{}

\newcommand{\pscript}[2]

{\setlength{\epsfxsize}{#2\hsize}

\centerline{\epsfbox{#1}}}

\newcommand{\etal}{{\em et al.}}

\newcommand{\GMC}{GreedyMaxClique\xspace}

\newcommand{\kCore}{\textit{k}-Core\xspace}

\newcommand{\CP}{CP\xspace}

\newcommand{\IXP}{IXP\xspace}

% References

\newcommand{\algoref}[1]{Algorithm~\ref{#1}}

\newcommand{\figref}[1]{Figure~\ref{#1}}

\newcommand{\chapheadref}[1]{Chapter~\ref{chap:#1}}

\newcommand{\secheadref}[1]{Section~\ref{sec:#1}}

\newcommand{\appheadref}[1]{Appendix~\ref{head:#1}}

%\newcommand{\eqnref}[1]{(\ref{eqn:#1})}

%\newenvironment{proof}{\noindent{\bf Proof.}\ \ }{\hfill \Box}

% Calligraphic letters

\newcommand{\cA}{{\cal A}}

\newcommand{\cB}{{\cal B}}

\newcommand{\cC}{{\cal C}}

\newcommand{\cD}{{\cal D}}

\newcommand{\cE}{{\cal E}}

\newcommand{\cL}{{\cal L}}

\newcommand{\cM}{{\cal M}}

\newcommand{\cS}{{\cal S}}

\newcommand{\cT}{{\cal T}}

\newcommand{\cV}{{\cal V}}

\newcommand{\cN}{{\cal N}}

% Boxes

\newenvironment{Boxedminipage}

{\begin{Sbox}\begin{minipage}}

{\end{minipage}\end{Sbox}\ovalbox{\TheSbox}}

\newenvironment{Boxedminipage1}

{\begin{Sbox}\begin{minipage}}

{\end{minipage}\end{Sbox}\shadowbox{\begin{Bcenter}\TheSbox\end{Bcenter}}}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% An environment for writing programs with dynamic ref and indentation %%

%% Remarks send to shavitt@ieee.org %%

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

\newcounter{LineNum}

\newcounter{AlgNum}

\newcommand{\In} {\hspace\*{3em}}

\newcommand{\I} {\item}

\newcommand{\II} {\item\hspace\*{.75em}}

\newcommand{\III} {\item\hspace\*{1.5em}}

\newcommand{\IV} {\item\hspace\*{2.25em}}

\newcommand{\V} {\item\hspace\*{3em}}

\newcommand{\SI} {\hspace\*{.6em}}

\newcommand{\SII} {\hspace\*{.6em}}

\newcommand{\SIII} {\hspace\*{.6em}}

\newcommand{\SIV} {\hspace\*{0.6em}}

\newcommand{\SV} {\hspace\*{3em}}

\newcommand{\Rem}[1] {$\ll$ {\it #1} $\gg$}

\newsavebox{\savepar}

\newenvironment{alg}[2] { % The parameters: width; the algorithm name

\baselineskip=11pt\vskip 12pt

\catcode`\#=12\catcode`\&=12

\obeyspaces %\tt

\def\par{\leavevmode\endgraf}

\obeylines\parindent=0pt\parskip=0pt

\begin{center}

\begin{lrbox}{\savepar}

\stepcounter{AlgNum}

\begin{minipage}{#1}

%{\bf Algorithm #2}

\begin{list} {\hspace\*{1em}\arabic{LineNum}.}

{\usecounter{LineNum}\setlength{\itemsep}{0in}}

}

{\end{list}\end{minipage}\end{lrbox}\fbox{\usebox{\savepar}}\end{center}}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%%%%%%% End of the writing programs environment %%%%%%%

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% Line Spacing (e.g., \ls{1} for single, \ls{2} for double, even \ls{1.5})

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

\newcommand{\ls}[1]

{\dimen0=\fontdimen6\the\font

\lineskip=#1\dimen0

\advance\lineskip.5\fontdimen5\the\font

\advance\lineskip-\dimen0

\lineskiplimit=.9\lineskip

\baselineskip=\lineskip

\advance\baselineskip\dimen0

\normallineskip\lineskip

\normallineskiplimit\lineskiplimit

\normalbaselineskip\baselineskip

\ignorespaces

}

\newcommand{\rem}[1]{}

%\makeatletter

%\def\boxeditem{%

% \@ifnextchar[ \@boxeditem{\@noitemargtrue\@boxeditem[\@itemlabel]}}

%\def\@boxeditem[#1]{\item[#1]\mbox{}\\}

%\makeatother

\makeatletter

\def\boxeditem{%

\@ifnextchar[ \@boxeditem{\@noitemargtrue\@boxeditem[\@itemlabel]}}

\def\@boxeditem[#1]{\item[#1]\mbox{}\\\hspace\*{\dimexpr-\labelwidth-\labelsep}}

\makeatother

\makeatletter

\def\namedlabel#1#2{\begingroup

#2%

\def\@currentlabel{#2}%

\phantomsection\label{#1}\endgroup

}

\makeatother

\makeatletter

\pgfplotsset{

reduce to/.style args={every#1except between values#2and#3}{%

/pgfplots/x filter/.code={%

\let\pgfmathreserved\pgfmathresult

\def\myswitch{1}%

\pgfmathparse{##1>#2}%

\ifpgfmathfloatcomparison

\pgfmathparse{##1<#3}%

\ifpgfmathfloatcomparison

\def\myswitch{0}%

\fi%

\fi%

\let\pgfmathresult\pgfmathreserved

\ifnum1=\myswitch%

\pgfmathsetmacro\temp{int(mod(\coordindex,#1))}%

\ifnum0<\temp

\let\pgfmathresult\pgfutil@empty

\fi%

\fi%

}

}

}

\makeatother

\makeatletter

\DeclareRobustCommand{\cnameref}[1]{%

\namecref{#1} \nameref{#1}%

}%

\DeclareRobustCommand{\Cnameref}[1]{%

\nameCref{#1} \nameref{#1}%

}

\makeatother

\newcommand\*{\IsInteger}[1]{%

\IfInteger{#1}{#1}{ }%

}%

%Text defines

\newcommand{\tspan}{{$t$-{\em spanner\/}}}

\newcommand{\compositeA}{{$VCS\_1$ }}

\newcommand{\compositeB}{{$VCS\_2$ }}

\newcommand{\tspanAdd}{{\em Additive $t$-spanner\/}}

\newcommand{\jndType}[1]{#1 JND\SI}

\newcommand{\minJND}{\jndType{Minimum}}

\newcommand{\wantedJND}{\jndType{Wanted}}

\newcommand{\odedw}{Oded Starwitsky\SI}

\newcommand{\JND}[1][\stalpha]{\ensuremath{JND(#1)}}

\newcommand{\fha}{\ensuremath{f\_{Input~Hearing~Aid}(t)}}

\newcommand{\sha}{\ensuremath{\underline{S}^{HA}}}

\newcommand{\dxi}{\ensuremath{\dot{\xi}}}

\newcommand{\halpha}{\ensuremath{\hat{\alpha}}}

%\newcommand{\dalpha}[1]{\ensuremath{\delta\alpha}}

\newcommand{\dalpha}[1][]{%

\ensuremath{\xifblank{#1}{\Delta\alpha}{\Delta\alpha\textsubscript{#1}\xspace}}

}

\newcommand{\dlalpha}[1][]{%

\ensuremath{\dalpha[\text{level}\ifstrnum{#1}{\ifnumgreater{#1}{0}{+#1}{#1}}{ #1}]}

}

\newcommand{\voltihc}{\ensuremath{V\_{ihc}}}

\newcommand{\eqr}[1]{Eq.\eqref{eq:#1}}

\newcommand{\tbr}[1]{Table \vref{tab:#1}}

\newcommand{\cheref}[1]{Chapter \ref{sec:#1}}

\newcommand{\conv}{\ast}

\newcommand{\cochposition}{Cochlear Longitudal Position}

\def\FullBox{\hbox{\vrule width 8pt height 8pt depth 0pt}}

\newcommand{\qqqed}{\;\;\;\FullBox}

%\newtheorem{theorem}{Theorem}[section]

%\newtheorem{definition}{Definition}[section]

%\newtheorem{lemma}[theorem]{Lemma}

%\newtheorem{fact}[theorem]{Fact}

%\newenvironment{proofof}[1]{\noindent{\bf Proof of {#1}:~~}}{\(\qqqed\)}

% Define bar chart colors

%

\definecolor{bblue}{HTML}{4F81FD}

\definecolor{rred}{HTML}{F0504D}

\definecolor{ggreen}{HTML}{9BEE59}

\definecolor{ppurple}{HTML}{9F4C7C}

\newcommand{\degree}{{\ensuremath{^{\circ}}}}

\newcommand{\lowspeechfrequency}{{\ensuremath{500Hz}}}

\newcommand{\criticalspeechfrequency}{{\ensuremath{4KHz}}}

\newcommand{\highspeechfrequency}{{\ensuremath{6KHz}}}

\DeclareMathOperator{\di}{d\!}

\newcommand{\recorded}{recorded signal\xspace}

\newcommand{\oxsi}{\ensuremath{\dot{\xi}}}

\newcommand{\aspl}{\ensuremath{p\_0}}

\newcommand{\asploded}{\ensuremath{1.5\cdot 10^{-8}}}

\newcommand{\xihc}{\ensuremath{\oxsi\_{ihc}}}

\newcommand{\psihc}{\ensuremath{\psi\_{ihc}}}

\newcommand{\hihc}{\ensuremath{h\_{ihc}}}

\newcommand{\etaac}{\ensuremath{\eta\_{AC}}}

\newcommand{\etadc}{\ensuremath{\eta\_{DC}}}

\newcommand{\signaltonormalize}{\ensuremath{\chi}}

\newcommand{\starred}[1]{\ensuremath{{#1}^{\!\*}}}

\newcommand{\rsqrt}[2][]{\ensuremath{\inv{\sqrt[#1]{#2}}}}

\newcommand{\stalpha}{\ensuremath{\starred{\alpha}}}

\newcommand{\sumsections}{\ensuremath{\sum\limits\_{x=1}^{Sections}}}

\newcommand{\sumfibers}{\ensuremath{\sum\limits\_{\forall AN \in (HSR,MSR,LSR)}^{}}}

\newcommand{\deltat}{\ensuremath{\Delta t}}

\newcommand{\dtau}{\ensuremath{\Delta \tau}}

\newcommand{\tdel}{\ensuremath{t\_{\delta}}}

\newcommand{\deltax}{\ensuremath{\Delta x}}

\newcommand\*\Eval[2]{\left.#1\right|\_{#2}}

\newcommand\fnorm[1]{\ensuremath{f\_{#1}^{norm}}}

\newcommand{\fnyq}{\ensuremath{F\_{nyq}}}

\newcommand{\unaryminus}{\scalebox{0.5}[1.0]{\( - \)}}

%\newcommand{\tkfill}{orange\!30}

%\newcommand{\tkgeneral}{minimum width=3cm, minimum height=1cm,text centered, draw=black, fill=\tkfill}

\tikzstyle{basecolors} = [minimum width=3cm,

minimum height=1cm,

text centered,

drop shadow,

draw=black, fill=orange!45]

\tikzstyle{operatorcolors} = [minimum width=5mm,

minimum height=5mm,

text centered,

drop shadow,

draw=black, fill=blue!45]

\tikzstyle{startstop} = [rectangle, rounded corners,basecolors]

\tikzstyle{operator} = [circle,operatorcolors]

\tikzstyle{stop} = [rectangle, rounded corners,basecolors,minimum width =7cm]

\tikzstyle{process} = [rectangle, basecolors]

\tikzstyle{initializer} = [process,fill=blue!45]

\tikzstyle{releaser} = [process,fill=red!45]

\tikzstyle{IOCommand} = [process,fill=red!45]

\tikzstyle{desicion} = [diamond, basecolors,aspect=2,text width =3cm]

\tikzstyle{arrow} = [draw,-latex',thick,->,>=stealth]

\tikzstyle{connector} = [draw,-latex',thick]

\newcommand{\lstfont}[1]{\color{#1}\scriptsize\ttfamily}

\newtoggle{InString}{}% Keep track of if we are within a string

\togglefalse{InString}% Assume not initally in string

\newcommand\*{\ColorIfNotInString}[1]{\iftoggle{InString}{#1}{\color{lime!35}#1}}%

\newcommand\*{\ProcessQuote}[1]{#1\iftoggle{InString}{\global\togglefalse{InString}}{\global\toggletrue{InString}}}%

\lstset{literate=%

{"}{{{\ProcessQuote{"}}}}1% Disable coloring within double quotes

{'}{{{\ProcessQuote{'}}}}1% Disable coloring within single quote

{0}{{{\ColorIfNotInString{0}}}}1

{1}{{{\ColorIfNotInString{1}}}}1

{2}{{{\ColorIfNotInString{2}}}}1

{3}{{{\ColorIfNotInString{3}}}}1

{4}{{{\ColorIfNotInString{4}}}}1

{5}{{{\ColorIfNotInString{5}}}}1

{6}{{{\ColorIfNotInString{6}}}}1

{7}{{{\ColorIfNotInString{7}}}}1

{8}{{{\ColorIfNotInString{8}}}}1

{9}{{{\ColorIfNotInString{9}}}}1

}

\lstset{

language=[ANSI]C++,

showstringspaces=false,

backgroundcolor=\color{black!90},

basicstyle=\lstfont{white},

identifierstyle=\lstfont{white},

keywordstyle=\lstfont{magenta!40},

captionpos=b,

numberstyle=\color{white},

stringstyle=\lstfont{cyan},

moredelim=[s][\ttfamily]{<<<}{>>>},

commentstyle=\lstfont{yellow!30},

emph={

cudaMalloc, cudaFree,

\_\_global\_\_, \_\_shared\_\_, \_\_device\_\_, \_\_host\_\_,

\_\_syncthreads,

},

emphstyle={\lstfont{green!60!white}},

breaklines=true,

classoffset=1,

morekeywords={blockIdx,threadIdx,blockDim},keywordstyle=\color{blue!40},

}

\def\at{

\left.

\vphantom{\int}

\right|

}

% achronysm

\DeclareAcronym{ohc}{

short={OHC},

long=Outer Hair Cells,

extra={Muscle cells with structured hair like that connecting the amplifying membranes in the cochlea \cite{hair-cells}. They mechanically amplify sound pressure.},

class=abbrev

}

\DeclareAcronym{ac}{

short={AC},

long=Alternating Current,

class=abbrev

extra={Sinusoidally alternating electrical current.},

}

\DeclareAcronym{dc}{

short={DC},

long=Direct Current,

class=abbrev

extra={An electrical current that is constant in time.},

}

\DeclareAcronym{ow}{

short={OW},

long=Oval Window,

extra={Membrane opening that connects the middle ear to the cochlea liquid tube.},

class=abbrev

}

\DeclareAcronym{ihc}{

short={IHC},

long=Inner Hair Cells,

extra={Muscle cells with structured hair like that connecting the amplifying membranes in the cochlea from one side and auditory nerves on the other side \cite{hair-cells}. They transduce mechanical vibrations into electrical signals and also amplify the signal.},

class=abbrev

}

\DeclareAcronym{jnd}{

short={JND},

long=Just Noticeable Difference,

extra={The minimum difference between a signal and a reference level for sensory detection.},

class=abbrev

}

\DeclareAcronym{an}{

short={AN},

long=Auditory Nerve,

extra={Neural cells connected to the cochlea; used to detect auditory signals.},

class=abbrev

}

\DeclareAcronym{anr}{

short={ANR},

long=Auditory Nerve Response,

extra={ Amplitude of electrical spikes fired by auditory nerves.},

class=abbrev

}

\DeclareAcronym{nhpp}{

short={NHPP},

long=Nonhomogeneous Poisson Process,

extra={A memoryless process of randomly occurring events so that inter-arrival time is not constant.},

class=abbrev

}

\DeclareAcronym{cpu}{

short={CPU},

long=Central Processing Unit,

extra={Electronic circuit capable of executing instructions stored in the main memory of a computer. Compared with the GPU, the CPU has more cache memory per core and is used as the control unit for the computer. Compared with the GPU, the CPU is mainly used for massively parallel computing programs.},

class=abbrev

}

\DeclareAcronym{gpu}{

short={GPU},

long=General Processing Unit,

extra={Electronic circuit capable of executing in parallel the same instructions on multiple data segments. Used mainly for physical simulations involving machine learning, deep-learning algorithms, and graphics.},

class=abbrev

}

\DeclareAcronym{sfu}{

short={SFU},

long=Special Functional Unit,

extra={Hardware that implements complex mathematical functionality on NVidia's \ac{gpu}, such as division and logarithms. The functions are approximations but are calculated much faster the software-implemented alternative in some cases.},

class=abbrev

}

\DeclareAcronym{hl}{

short={HL},

long=Hearing Loss,

extra={Difference between actual hearing level and normal hearing per frequency, measured in dB.},

class=abbrev

}

\DeclareAcronym{ha}{

short={HA},

long=Hearing Aid,

extra={Electromechanical device that amplifies sound to assist hearing impaired patients.},

class=abbrev

}

\DeclareAcronym{qol}{

short={QoL},

long=Quality of Life,

extra={Quantified measurement of human wellness.},

class=abbrev

}

\DeclareAcronym{spl}{

short={SPL},

long=Sound Pressure Level,

extra={Force applied by air vibration on the ear relative to reference level; measured in dB.},

class=abbrev

}

\DeclareAcronym{splref}{

short={SPL Reference},

long=Sound Pressure Level Reference,

extra={ Pressure of sound wave at 0 dB.},

class=abbrev

}

\DeclareAcronym{nal}{

short={NAL},

long=National Acoustic Laboratories,

extra={Australian laboratories that created a method to calculate hearing-aid gain per hearing loss at a given frequency.},

class=abbrev

}

\DeclareAcronym{hd}{

short={HD},

long=Hard Drive,

extra={Computer hard drive.},

class=abbrev

}

\DeclareAcronym{nl}{

short={NL},

long=Noise Level,

extra={Magnitude of noise that interferes with signal to be detected by auditory nerves.},

class=abbrev

}

\DeclareAcronym{sl}{

short={SL},

long=Signal Level,

extra={Magnitude of signal that to be detected by auditory nerves.},

class=abbrev

}

\DeclareAcronym{pogo}{

short={POGO},

long=Prescription of Gain and Output,

extra={Function that maps hearing loss to hearing-aid-prescribed gain at frequencies characterized by half insertion gain and a constant dependence on frequency.},

class=abbrev

}

\DeclareAcronym{chh}{

short={CHH},

long=Children Hard of Hearing,

extra={Children that have hearing loss and require a hearing aid.},

class=abbrev

}

\DeclareAcronym{cnh}{

short={CNH},

long=Children with Normal Hearing,

extra={Children that have no hearing loss.},

class=abbrev

}

\DeclareAcronym{nh}{

short={NH},

long=Normal Hearing,

extra={Level of hearing for which a person does not need a hearing aid to detect auditory input.},

class=abbrev

}

\DeclareAcronym{crlb}{

short={CRLB},

long=Crem\’er-Rao Lower Bound,

extra={Lower boundary on the variance of estimator for a fixed but unknown parameter.},

class=abbrev

}

\DeclareAcronym{bm}{

short={BM},

long=Basilar Membrane,

extra={Stiff membrane that separates two liquid tubes inside the cochlea. Resonates in response to air pressure. Responds to high (low) frequency most strongly near the oval window (apex).},

class=abbrev

}

\DeclareAcronym{bmv}{

short={BMV},

long=Basilar Membrane Velocity,

extra={Velocity of oscillation per longitudinal section.},

class=abbrev

}

\DeclareAcronym{ai}{

short={AI},

long=All Information,

extra={Method to estimate hearing level that accounts for rate of neural spike and temporal position of spikes relative to each other.},

class=abbrev

}

\DeclareAcronym{rms}{

short={RMS},

long=Rate Mean Square,

extra={Method to estimate hearing level that accounts for the average rate of neural spikes in a given time window but not their position relative to each other.},

class=abbrev

}

\DeclareAcronym{hsr}{

short={HSR},

long=High Spontaneous Rate,

extra={Property of group of auditory nerves whereby their firing rate responds to small changes in BM velocity. Have high firing rate of spikes even in stimulationless environment},

class=abbrev

}

\DeclareAcronym{msr}{

short={MSR},

long=Medium Spontaneous Rate,

extra={Property of group of auditory nerves whereby their firing rate responds to medium changes in BM velocity. Have medium firing rate of spikes in stimulationless environment.},

class=abbrev

}

\DeclareAcronym{lsr}{

short={LSR},

long=Low Spontaneous Rate,

extra={Property of group of auditory nerves whereby their firing rate responds only to large changes in BM velocity. Have very low firing rate of spikes in stimulationless environment.},

class=abbrev

}

\DeclareAcronym{cuda}{

short={CUDA},

long=Compute Unified Device Architecture,

extra={Software development kit and application programming interface for parallel computing on CUDA-enabled hardware of NVidia.},

class=abbrev

}

\DeclareAcronym{dB}{

short={dB},

long=Decibels,

class=abbrev

}